The Origin and Spread of Pandemic Diphtheria

Arthur Newsholme.


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EPIDEMIC DIPHTHERIA

A RESEARCH
ON THE ORIGIN AND SPREAD OF THE DISEASE
FROM AN INTERNATIONAL STANDPOINT

BY

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INTRODUCTION.

The investigation embodied in the following pages has occupied my attention for several years, during which I have been gradually collecting the necessary data from every civilized country. It can scarcely happen that in such a complex task every single death-rate should have been accurately calculated, but the greatest care has been exercised, and I believe that very few errors will be found, and that such as may have occurred will not vitiate any conclusions stated in the body of the book.

Some measure of originality is claimed for the method of statement of the facts. The death-rate for each year is plotted out in diagrammatic form on a scale which is constant for all the diagrams throughout the book, with the exception of Figs. 12, 23 and 24. The necessity for tabular statements is thus avoided, as the death-rate for any given year can at once be ascertained by reading the scale attached to each diagram. Furthermore, the relative bulk of diphtherial mortality in different towns and countries can be seen in a manner which is much more impressive than a tabular statement of yearly death-rates, and more accurate than an average death-rate for a series of years. The avoidance of average death-rates for successive series of years obviates a source of error which, in my opinion, is most important and serious. The diagram enables the number of epidemics occurring in the period investigated to be exactly stated; while a comparison of the average death-rates may include periods which contain one, two, or more epidemics, according to the arrangement of the series, thus leading one possibly to think that the amount of disease has increased or decreased when the converse is true.

A statistical investigation based on official data of varying degree of accuracy is apt to be received with a modicum of incredulity, the judgment of the reader being prejudiced by erroneous preconceptions. While so many are ready to say that "anything can be proved by statistics," but few realize that without statistics nothing can be proved; and that unless complete ignorance is to persist, even defective statistics must be used to the full extent of their value. Nor is it sufficiently realized that perfectly valid conclusions can be drawn from imperfect statistics, when these are skilfully and honestly employed. In saying this, I have no wish—nor is there need—to suggest any distrust of the data on which the present treatise is based. The usual complaints against such statistical data may be classified under three or four heads: Firstly, the changes in nomenclature on which follow necessarily changes in the numbers under a given disease, not due to the varying mortality from this disease. Secondly, the incomplete character of the registration of deaths in a given town or country, which incompleteness gradually becomes diminished, and consequently comparison between recent and more remote years is to that extent vitiated. Thirdly, the fact that deaths from a disease do not necessarily form a correct index of its prevalence, as the fatality of diseases like diphtheria varies greatly. Fourthly, differences in the age constitution of the populations under comparison, which disturb any contrast of the actual amount of diphtheria prevalent.

1. The importance of the first of these objections has been minimised by giving, wherever the available data

exist, the death-rate from diphtheria in each diagram separately from that from croup. By this means the gradually increasing transference from croup to diphtheria can be seen at a glance; and the true facts become evident by an inspection of the combined curve for the two diseases. Other transferences than that of croup to diphtheria are of trifling consequence in the periods embraced within the statistics to be given.

2. The second objection may affect any comparison of relative amounts of diphtheria in different communities. It is obvious, however, that any error caused by it will be on the side of undue moderation of statement. Thus the extraordinary amount of diphtheria shown in the American diagrams would almost certainly be increased in many instances had the registration of causes of death been more complete. There is no sudden transition from incomplete to complete registration; and although the amount in any given year may be understated, the position of this part of the curve in relation to the parts for neighbouring years forms a trustworthy guide as to whether it is a year of epidemic or inter-epidemic prevalence of diphtheria. The same argument applies to all the diagrams. The amount of diphtheria may in some of the diagrams be understated, but the teaching of the diagrams as to which are the epidemic and which the inter-epidemic years can in each instance be confidently and implicitly accepted. *It is on the position rather than on the height or depth of the crests and troughs of the epidemic waves that the main teaching of this work is based,* and in that respect it is believed to be absolutely accurate.

3. That the present work almost throughout deals with *deaths* from and not with total *cases* of diphtheria may be regarded by some as a limitation of its utility. After

most careful and detailed preliminary investigation, I deliberately adopted this course. In the first place, there were no countries, except the Scandinavian, in which records of a system of general compulsory notification of diphtheria were available for a sufficiently long series of years to make them valuable in a study of epidemiology. In the next place, the experience of compulsory notification of diphtheria in this country for the comparatively few years in which it has been commonly adopted, tends to show that cases which a few years ago would have escaped notification are now notified to a somewhat larger extent (see Fig. 50B).* Consequently deaths are in England a more reliable indication of prevalence than notifications. The same remark does not apply in Norway and Copenhagen, as may be seen by a glance at Figs. 48 and 49. The fatality of diphtheria in epidemic and in inter-epidemic periods forms an interesting subsidiary investigation, to which I can only devote one short chapter.

4. Diphtheria is a disease, four-fifths of the deaths from which occur in children under ten years of age. Consequently the comparison between the different towns and countries whose death-rates from diphtheria are graphically represented in the following pages is inexact in so far as the relative proportion of children under ten is not the same in these different populations. It has been quite impracticable to make any correction for varying age-distribution of the populations in different countries and towns.† I must, therefore, content myself

* For remarks modifying this statement see page 109.

† The extent of correction for variations in age-distribution of population may be gathered from the following examples:—In 1890, there were in Boston for every 100 persons at all ages 25·2 under 15 years of age, in Philadelphia 27·9, in New York 28·8, in Hamburg 32·1, while in London, in 1891, the percentage ages 0–15 was 32·6. It is evident that if correction for age-distribution of

with drawing attention to this source of error, *which is within very small limits,* and could furthermore, as previously remarked, only slightly affect the height of any particular curve without altering in the least the relative height of its constituent parts, with which I am almost solely concerned.

A glance at the diagrams in the following pages shows that in the majority of instances they relate to urban populations. In the case of London the diagrams have been subdivided (pages 57–9), so as to show the yearly death-rate in different districts of the metropolis; and more exact truth might have been attained had this been practicable for other great cities. Death-rates for rural districts have not been given, because they are difficult to secure for a sufficiently long series of years, and because with small populations accidental oscillations of yearly curves of mortality become exaggerated. This fact makes the international study of diphtheria here detailed one of diphtheria as affecting chiefly urban communities (see page 138).

Having briefly discussed the trustworthiness of the facts set forth in the diagrams which form the statistical basis of this treatise, it remains for me to make a few remarks upon the main conclusions derived from these diagrams. These are two: firstly, that diphtheria spreads from town to town and from country to country, the means of spread being almost certainly personal infection; and secondly, that certain climatic conditions are necessary for the development of diphtheria on an epidemic, and still more for its development on a pandemic scale. In the

population were made, the result would be to increase to an appreciable extent the excess of diphtheria already displayed in the American diagrams.

first portion of the book, dealing with the prevalence of diphtheria in different countries, I have, throughout, attempted to discuss the epidemics in a given place as related in time to epidemics in neighbouring towns and countries, and to indicate the gradual progression of the disease. In reading this part of the book, geographical considerations should be borne in mind, and the atlas consulted, as the distances between towns in, for instance, the United States is immensely greater than between towns in England. The teaching as to gradual progression of the disease would have been clearer in certain instances had one constructed curves of monthly or quarterly instead of annual death-rates. Those who are aware of the laborious character and complexity of work of this kind will, however, readily forgive an omission to make the curves by this means more complete but at the same time less easy to follow.

In the second part of the book, I have dealt with the climatic conditions, in the absence of which diphtheria never becomes epidemic on a large scale. A superficial perusal of the book might produce the impression that these two factors are not consistent with each other. A more careful study will, I believe, prove that both are necessary. Diphtheria is spread chiefly by personal infection, but this infectivity is only operative on a large scale under the influence of the climatic conditions to be hereafter described.

This work would have been impracticable, but for the help of numerous distinguished statisticians and medical officers of health in all the countries dealt with in the following pages. Where no other reference is given, it may be assumed that the statistics are obtained from official reports. To many English medical officers of health I am greatly indebted for records embracing long series of years, often obtained with considerable difficulty. I also tender my cordial thanks to Dr. Bentzen, of Christiania; Dr. J. Bertillon, of Paris; Dr. Borthwick, of Adelaide; Dr. Grimshaw, Registrar-General of Ireland; M. Goseti, Venice; Mr. Goto Shimpei, Director-General of the Sanitary Bureau Home Department, Japan; Mr. F. L. Hoffmann, F.S.S., Newark, N.J.; Dr. Janssens, Brussels; Dr. Von Jûraschetz, Vienna; Herr Körosi, Buda-Pesth; Mr. George Leslie, Actuary to the Government of New Zealand; Dr. Linroth, of Stockholm; M. Martinez, Buenos Ayres; Dr. Mantez, Geneva; Dr. Pistor, Berlin; M. Ravizza, Milan; Dr. Reincke, Hamburg; Dr. Sandwith, Cairo; Mr. Symons, F.R.S.; Dr. Ashburton Thompson, of Sydney; the Chief Burgomasters, Antwerp and Rotterdam; the Directors of the Statistical Bureaux of Breslau, Leipzig and Trieste; the English Consul, Lisbon; M. Potzniakoff, Moscow; for help rendered, in some instances involving great trouble. If I have omitted any from this list who should have appeared in it, I trust they will not think I am ungrateful for the generous help which they have rendered in an investigation, the complexity of detail of which has sometimes been almost overwhelming.

CHAPTER I.

NORTH AND SOUTH AMERICA.

The vital statistics of the cities included in the following diagrams are not all equally complete, and some allowance has to be made in this respect. Thus in Michigan, according to Dr. Baker (report on the Vital Statistics of Michigan, 1892), in 1881 the registered mortality from all causes was probably not more than 60 per cent. of the actual mortality, and presumably a similar proportion would apply for diphtheria. It is evident, however, that this incompleteness of registration of deaths will not vary in extent suddenly, and will therefore not materially affect any conclusions that may be drawn from the accompanying diagrams as to epidemic and non-epidemic years of diphtheria. There can be no reasonable hesitation in accepting the teaching of these diagrams in this respect as sufficiently accurate for all practical purposes. It is the fluctuations observable in the heights of the diagram, rather than the actual height in any given instance, that should be noted.

We will commence our consideration of the American returns of diphtheria mortality with those for the New England States, as their statistics are more complete and accurate than those of most other States.

The mortality from diphtheria for the whole of Massachusetts is shown in Fig. 1 :—

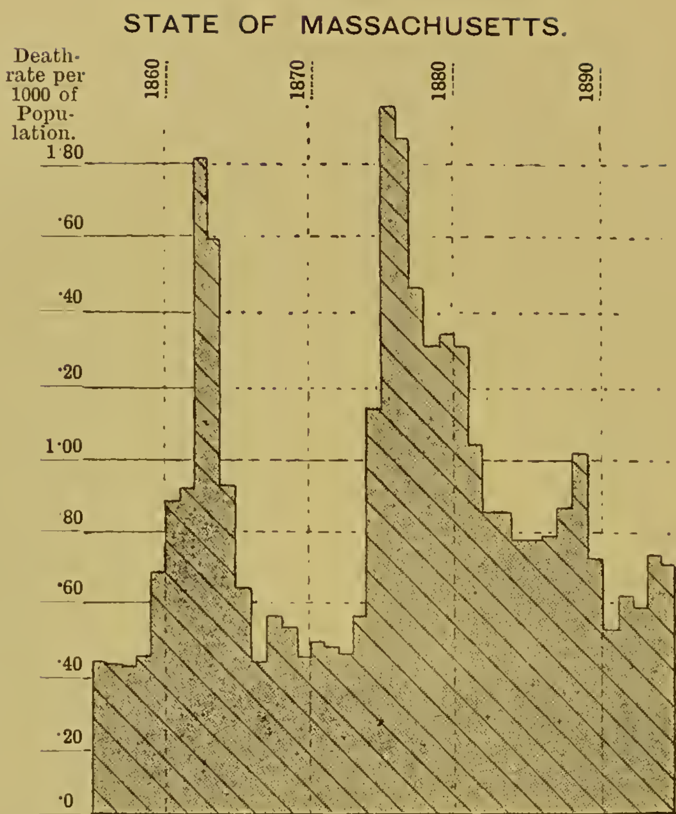


Fig. 1.

Note.—In this and the following diagrams,  indicates that the statistics for diphtheria and croup are stated in combination (as in Figs. 1 and 2);  indicates the death-rate from diphtheria alone (as in Fig. 2);  indicates the death-rate from croup alone (as in Fig. 2).

It will be seen that for the years 1856–94 inclusive, the lowest death-rate from diphtheria *plus* croup was 43 per 100,000 inhabitants in 1858, the highest 196 in 1876, the total endemic prevalence of the disease being very great, as shown by a glance at Fig. 1. It is possible that the minimum year, 1858, had really more diphtheria and croup than is indicated in the diagram, owing to the deficient recognition of the disease at that period. After the great epidemic culminating in 1863, a marked remission occurred, the second great epidemic reaching its maximum in 1876–77, after which the amount of the disease remaining endemic was greater than that following the first epidemic.

Boston.—During the 35 years 1861–1895, the death-rate from diphtheria *plus* croup in this city varied from 35 per 100,000 inhabitants in 1872 to 218 in 1881. The proportion between diphtheria and croup is shown for the years 1880–94 in Fig. 2. The general shape of the epidemic curve is the same whether we take diphtheria alone or this in conjunction with croup; and the same remark applies to most of the diagrams to be subsequently considered. It will be observed that there was a great epidemic of the disease culminating in 1863–4, and that then an interval of comparative freedom from it lasted for ten years. In 1875–6 another great epidemic occurred. With but a short and imperfect ebb of the epidemic tide, a still more fatal epidemic occurred in 1880–1, followed by later epidemics culminating in 1889 and 1894. Between these maximal diphtheria years a large amount of diphtheria was endemically present, the death-rate from 1875–95 inclusive never being lower than 62 per 100,000 (in 1891).

Providence.—In Providence during the years 1868–75 the death-rate from diphtheria *plus* croup varied from 25 per 100,000 in 1868 to 357 in 1877. The high death-rate in 1877 represented the acme of a great epidemic in 1876–79. Following on this were smaller epidemics in 1881, in 1886–90, and in 1895 (Fig. 3).

BOSTON.

(Population: 1870—250,500; 1890—448,400.)

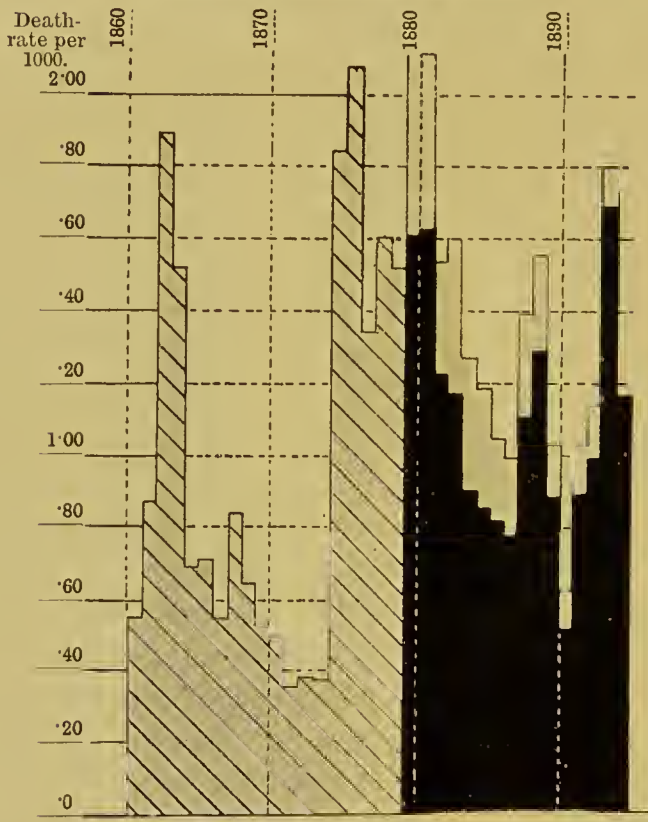


Fig. 2.

New York.—The death-rate from diphtheria *plus* croup was at its lowest (69[1]) in 1873, and at its highest (276) in 1877, a year earlier than in Providence, and two to three years earlier than the corresponding maximum in Boston.

[1] Where not otherwise stated the deaths are all given in their proportion to 100,000 of the population. The scale on all the diagrams gives the death-rate per 1,000 of the population.

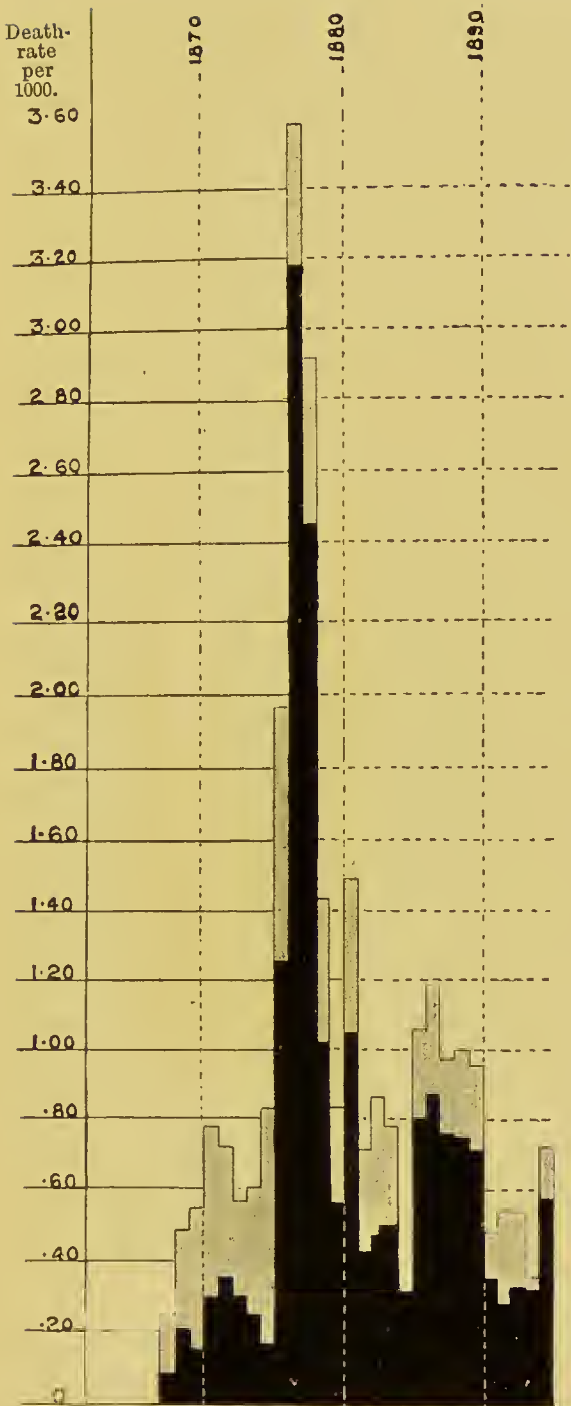


Fig. 3.

PROVIDENCE.
(Population : 1870—68,904 ; 1890—132,146.)

In 1881 a second maximum occurred, closely approaching the first in height, while later epidemics of not much smaller magnitude culminated in 1887 and in 1894 respectively.

NEW YORK.

(Population: 1880—1,111,941; 1890—1,617,997.)

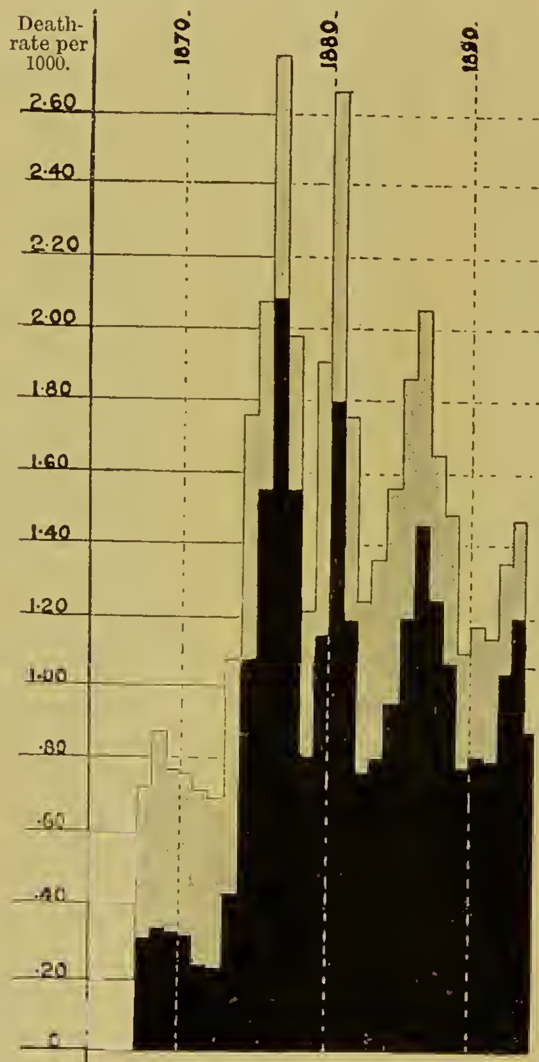


Fig. 4.

Brooklyn.—Being close to New York, the curve of its diphtheria mortality is, as might have been anticipated, almost identical with that of the latter city. The death-rate from diphtheria in Brooklyn reached 215 in 1875, and sunk to its minimum of 59 in 1884, as compared with

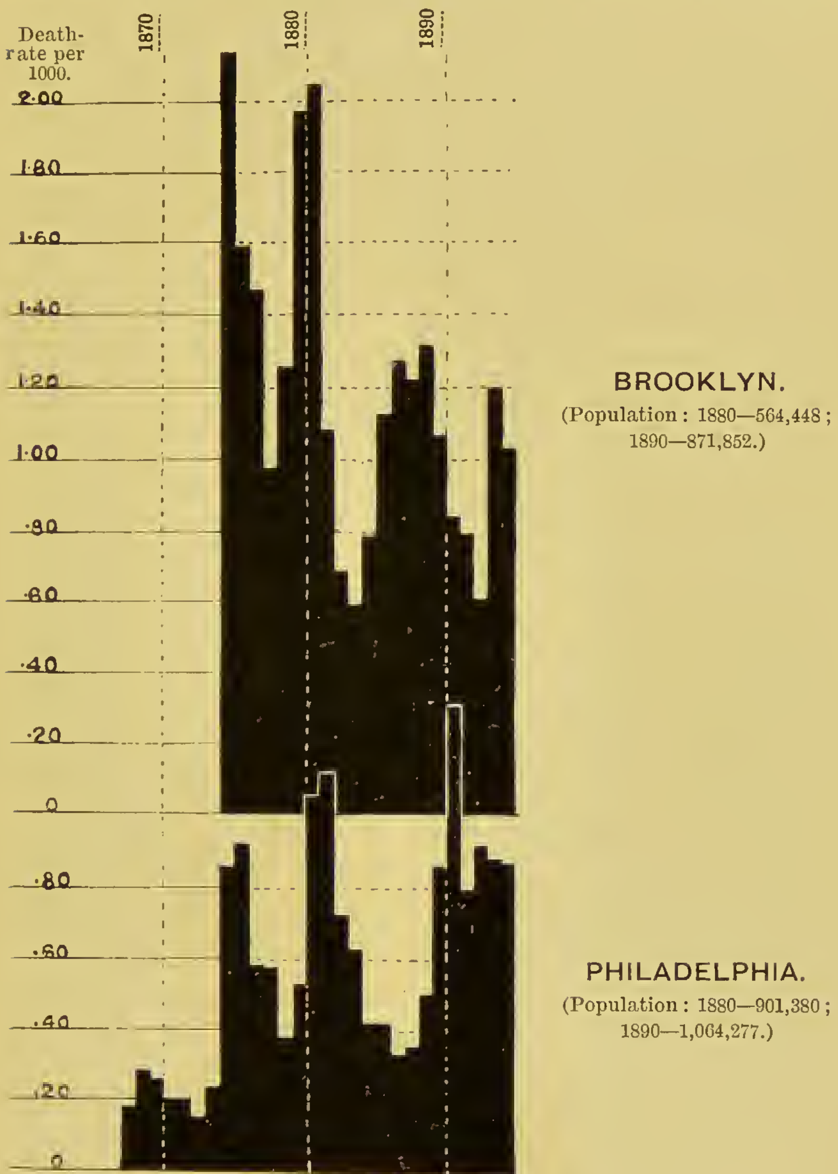


Fig. 5.

a maximum for New York for diphtheria of 208 in 1877, and a minimum during the same period for the two cities (1875–95) of 78 in 1890.

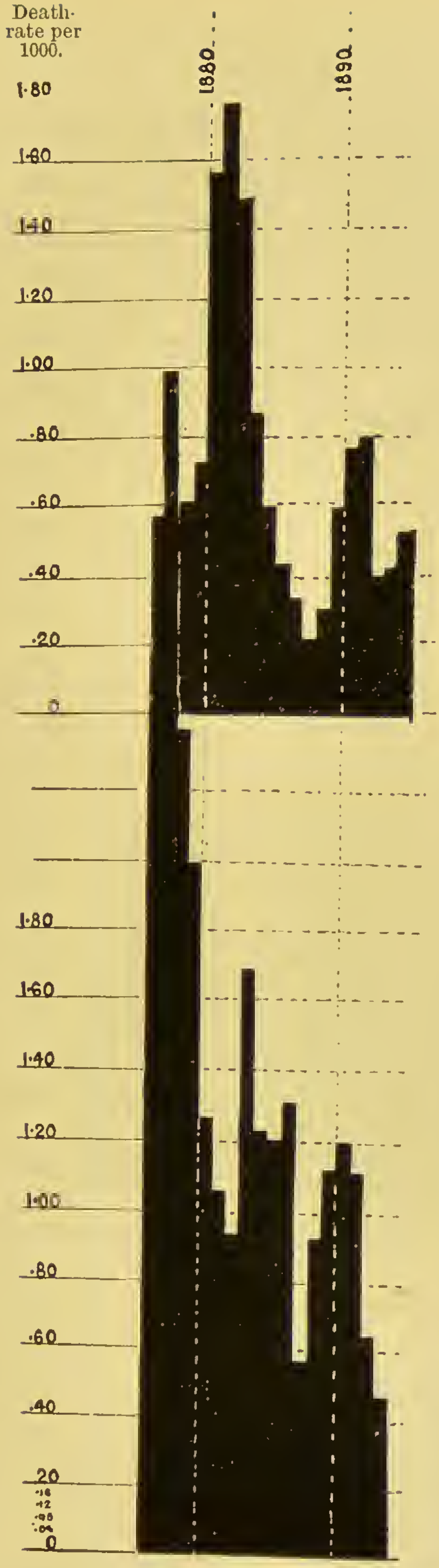
Philadelphia.—The death-rate from diphtheria has a considerably smaller range, and is absolutely lower than in the other cities hitherto described. A portion of this difference (but only a portion) may be caused by a smaller proportion of children under five years of age in its population; diphtheria being chiefly fatal in childhood. As bearing on this point, it is interesting to note that in 1890—the census year—the proportion of children under five years to the total population at all ages was 9·9 per cent. in Philadelphia as compared with 11·7 per cent. in New York. The death-rate from diphtheria in Philadelphia ranged from 18 in 1868 to 131 in 1891.

A comparative study of the diagrams already given seems to indicate a gradual spread of infection from city to city. Thus taking the period comprised by all the curves from 1870 onwards, it is evident that Boston's first epidemic culminated in 1875–6, Providence's first epidemic in 1876–7, New York's and Brooklyn's first epidemic in 1876–7, and that of Philadelphia, 1875–6. The 1880–81 epidemic in New York and Brooklyn occurs in 1881–3 in Philadelphia; and the 1886–89 epidemic of these cities culminated in 1891 in Philadelphia.

Baltimore.—This city furnishes in its 1881–83 and its 1891–2 epidemics further support of the view that the infection of diphtheria gradually spread from the eastern sea-board of the States westward and southward. The maximum death-rate from diphtheria was 173 in 1882 and the minimum 22 in 1888.

Pittsburgh.—The returns for Pittsburgh extend from 1877 to 1894, the maximum death-rate from diphtheria being 340 in 1878, and the minimum 47 in 1894.

The great epidemic of 1877–80 evidently corresponds to the 1875–76 epidemic in Boston, and the 1884–87 epidemic to the 1880–83 epidemic in Boston.



BALTIMORE.
(Population: 1880—410,000; 1890—455,427.)

PITTSBURGH.
(Population: 1880—156,389; 1890—238,617.)

Fig. 6.

Cincinnati.—In this city the death-rate from diphtheria *plus* croup ranged in the period 1868–95 from 165 in 1890 to 50 in 1875. The diagram for this city is remarkable for the comparative smallness as well as the lateness of the rise in the decennium 1871–80. Its maximum was in 1878, as compared with 1877 in New York. Similarly in the next decennium the maximum of diphtheria was reached in 1890, as compared with 1887 in New York.

CINCINNATI.

(Population: 1870—942,000; 1880—1,206,000.)

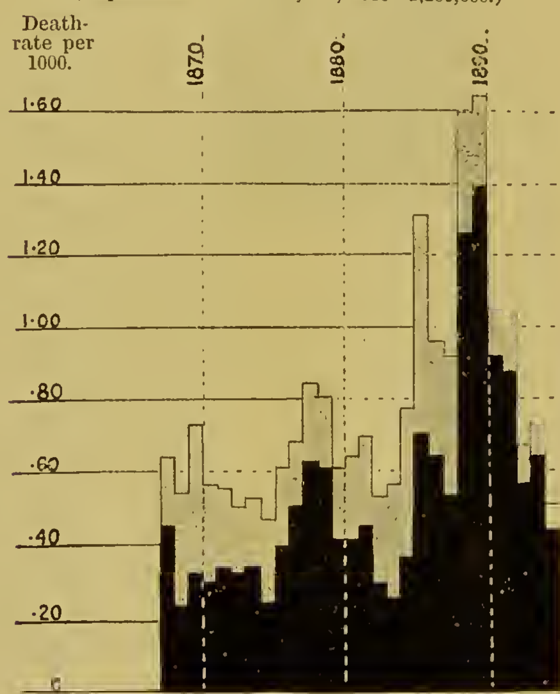


Fig. 7.

St. Louis.—During the period 1868–95, the death-rate from diphtheria *plus* croup ranged from 262 in 1887 to 26 in 1868. The epidemic in the decennium 1871–80, as judged by the combined curve for diphtheria and croup, reached its acme in 1876, earlier than in Cincinnati, contrary to what might have been expected on the assumption that the disease had travelled from east to west. In the decennium 1881–90 two great epidemics occurred almost commingling, and in 1895 there is what looks like the beginning of another large epidemic.

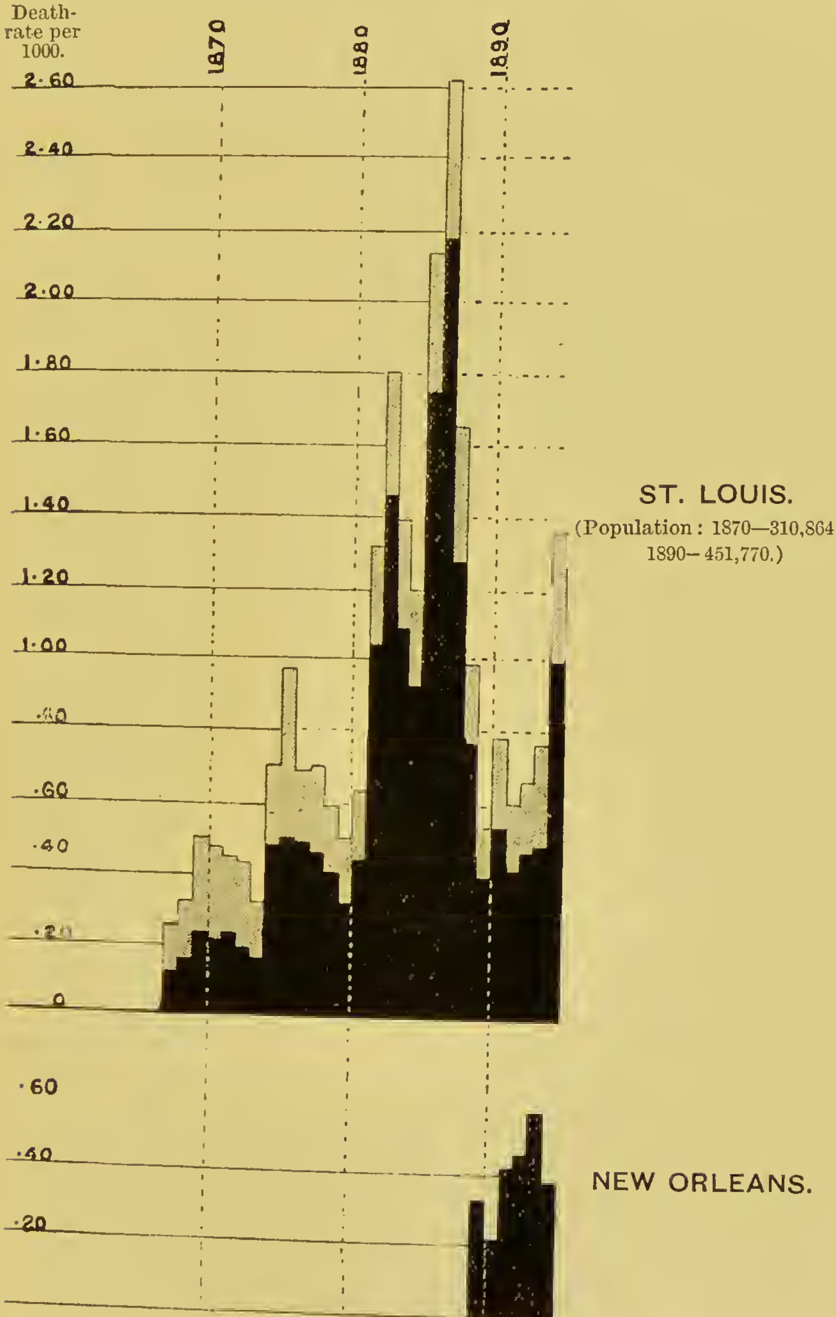


Fig. 8.

Denver, Colorado.—A return from this city shows that the death-rate from diphtheria *plus* croup, was 28 per 100,000 of the population in 1886; 84 in 1887; 141 in 1888; 114 in 1889; 261 in 1890; 154 in 1891; 74 in 1892; 85 in 1893; 46 in 1894; and 28 per 100,000 in 1895. The population had increased during this period from 70,000 to 145,000. The epidemic evidently reached its maximum in 1890, three years later and higher than the maximum in St. Louis.

New Orleans.—For this city on the Gulf of Mexico, the death-rates from diphtheria for the period 1890–95 are alone available. They show a death-rate (not including croup) varying from 22 in 1891 to 58 in 1894. Whether these rates indicate that during the years 1890–95, New Orleans was enjoying an inter-epidemic period, or whether this southern city enjoys a partial immunity from this disease, cannot with the data before us be stated with certainty.

Chicago.—The returns for this city are fortunately available from 1859 onwards. They show a large endemic prevalence of diphtheria and croup, with epidemics at irregular intervals. The highest death-rate from diphtheria *plus* croup was 291 in 1880, the lowest 42 in 1874. The only one of the preceding curves for a nearly equally long series of years is that of Boston. The comparison between Chicago and Boston shows that the earliest epidemic reached its maximum in 1860 in Chicago, not until 1863 in Boston. The curve for Boston it must be observed however only goes back to 1861. The years of incidence of the later epidemics almost coincided in the two cities, maxima being reached for both in 1876, in 1879–81, in 1887–89, and in 1894, the last maximum being much smaller in Chicago than in Boston.

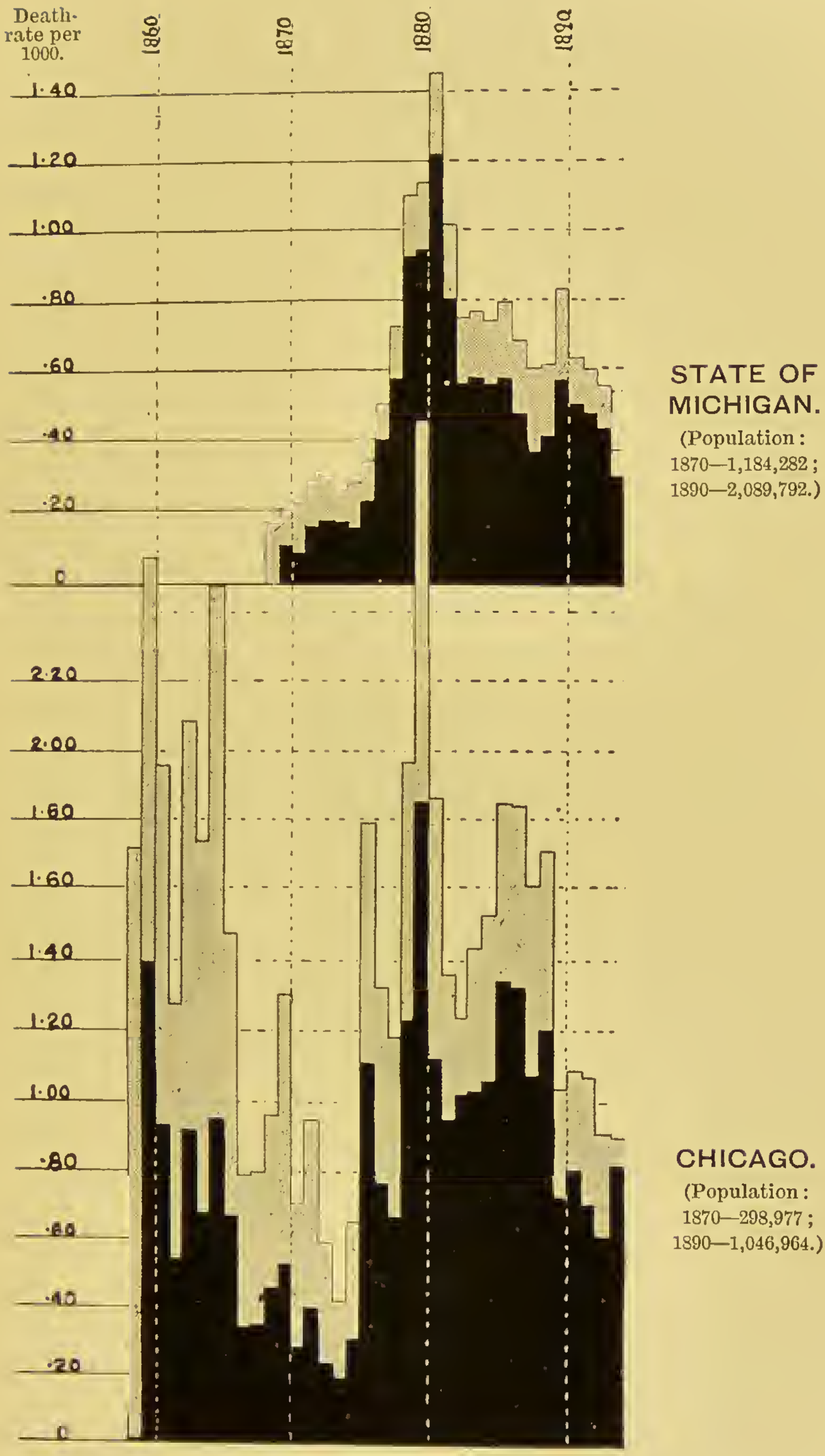

Death-rate per 1000.
1860
1870
1880
1890
1·40
1·20
1·00
·80
·60
·40
·20
0
STATE OF MICHIGAN.
(Population:
1870—1,184,282;
1890—2,089,792.)
2·20
2·00
1·80
1·60
1·40
1·20
1·00
·80
·60
·40
·20
0
CHICAGO.
(Population:
1870—298,977;
1890—1,046,964.)

Fig. 9.

Chicago being situate on Lake Michigan, though not in the State of that name, the similarity of the curves for the whole of the State of Michigan and for Chicago is interesting. The curve for the State of

MONTREAL.

(Population: 1872—120,759; 1894—241,748.)

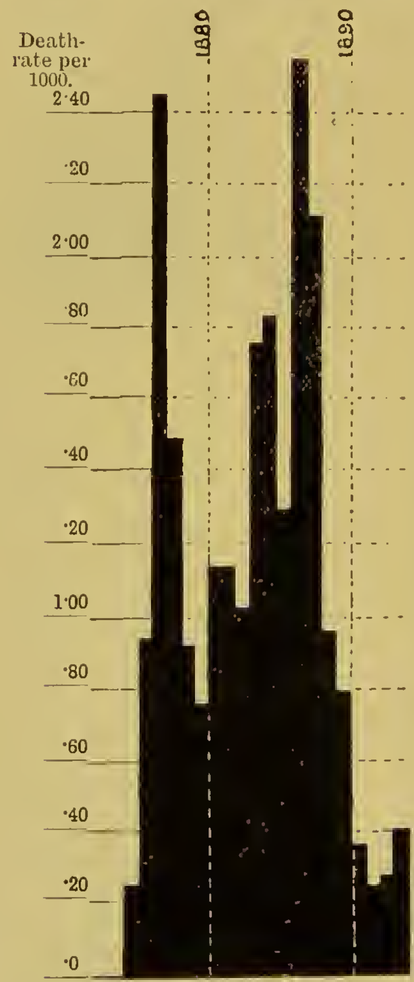


Fig. 10.

Michigan represents a fusion of a number of epidemics in its different parts, hence its greater smoothness than when a single city or district is plotted out.

Canada.

Only one return has been secured from Canada.

Montreal.—The death-rate from diphtheria in this city ranged during the years 1875–94 from 245 in 1877, and 259 in 1887 to 24 in 1892. There is an obvious resemblance between the curves for Montreal and for Chicago, as might have been expected in view of their geographical and commercial connections. The 1877–78 maximum in Montreal corresponds to the 1879–80 maximum in Chicago, while the 1884–85 and the 1887–88 maximum in Montreal are represented by the maximum of 1887–88 in Chicago. The total endemic amount of diphtheria in Montreal, like that in the great cities of the United States, is enormous, as can be seen by comparison with the curves of miniature size, though drawn on the same scale, which represent English experience (see pp. 30 to 43).

South America.

The only city from which a return is available is Buenos Ayres, and this only embraces the years 1888–95, the municipal office of statistics having been inaugurated in 1887.

Buenos Ayres.—The return gives diphtheria and croup together, and shows a death-rate which was 323 in 1888 and steadily fell to 61 in 1895. It is evident that diphtheria has during recent years been very severely prevalent. The death-rate from diphtheria *plus* croup in 1888 was higher than that for any American city in the years for which records are extant, with the exception of Providence in 1877, where it was 357.

This is a convenient opportunity for summarising the available data as to the epidemiology of diphtheria in the great American continent. It is assumed throughout that croup is chiefly the laryngeal form of diphtheria; but that the death returns from croup include an uncertain proportion of non-diphtheritic laryngitis. Those

BUENOS-AYRES.

(Population: 1887—437,875; 1896—712,095.)

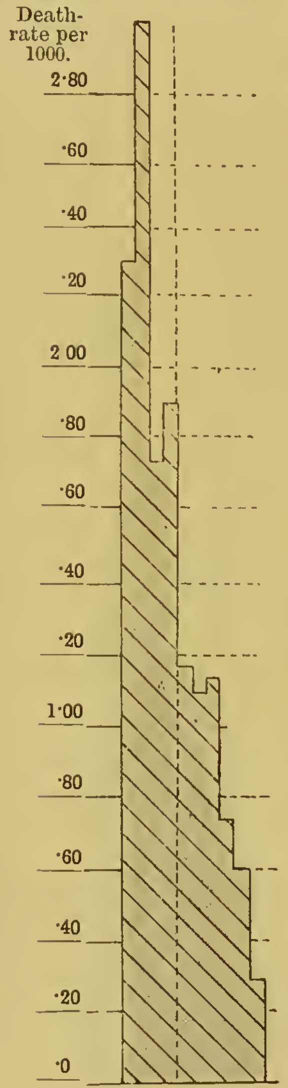


Fig. 11.

of the curves which give croup separately from diphtheria—and this has been consistently carried out in all cases in which such separate statistics could be obtained—clearly indicate that whether the diphtheria curve or the curve for croup and diphtheria combined is surveyed, the conclusions will in nearly every instance be identical.

City.	Years of observation.	Diphtheria *plus* Croup.		Diphtheria alone.		Mean Death-rate for the entire period.		Remarks.
		Highest Death-rate.	Lowest Death-rate.	Highest Death-rate per 100,000.	Lowest Death-rate per 100,000.	Diphtheria *plus* Croup.	Diphtheria alone.	
Boston . . .	1861–95	218 in 1881	35 in 1872	(163 in 1881)	(51 in 1891)	116*	(100*)	The figures in brackets refer to the period 1880–95.
Providence .	1868–95	357 in 1877	25 in 1868	314 in 1877	8 in 1868	93	69	
New York. .	1868–95	276 in 1877	68 in 1868	208 in 1877	23 in 1873	161	109	
Brooklyn . .	1875–95	—	—	215 in 1875	61 in 1893	—	114	
Philadelphia.	1868–95	—	—	131 in 1891	18 in 1868	—	64	
Baltimore . .	1878–95	—	—	173 in 1882	41 in 1893	—	72	
Pittsburg . .	1877–94	—	—	340 in 1878	47 in 1894	—	129	
Cincinnati .	1868–95	165 in 1890	50 in 1875	140 in 1890	23 in 1869	79	55	
St. Louis . .	1868–95	357 in 1877	25 in 1868	314 in 1877	8 in 1868	96	69	
Denver . . .	1886–95	154 in 1891	28 in 1886	—	—	110	—	
New Orleans.	1889–95	—	—	156 in 1894	55 in 1891	—	40	
Chicago . .	1859–94	255 in 1860	42 in 1874	141 in 1860	20 in 1874	140	77	
Montreal . .	1875–94	—	—	259 in 1887	24 in 1892	—	109	
Buenos Ayres	1888–95	388 in 1888	61 in 1895	—	—	136	—	

* The mean death-rate for this city is obtained by summing the annual death-rates and dividing the sum by the number of years. In all the cases not thus particularised, the mean death-rate has been obtained by the more accurate method of adding together the deaths and the populations respectively for the whole series of years, and then ascertaining the death-rate on this aggregate population.

Certain cautions must be observed in interpreting the true significance of the data in the preceding table.

Note first, that although for the sake of convenience the years of maximum and minimum mortality from diphtheria and croup have been given and the figures for these years, the course of the epidemics in each city can only be gathered with strict accuracy from the diagrams given in the preceding pages.

Note secondly, that the mean death-rates given in the last columns of the table, although they give a rough idea of the relative mortality in each city, do this only with certain reservations. (*a*) The period of years for which the mean death-rate is taken does not coincide in all instances. (*b*) Even when an average is struck for the same series of years, there remains the fallacy that one city may have happened to have say three epidemics and another four during the given term of years. It might thus happen, for instance, that if two or three additional years had been included in the series, the place of the two cities would have been reversed as regards their mean death-rate from diphtheria. This fallacy is inherent to all average death-rates for a series of years for any epidemic disease, and is the chief reason why in the present investigation the *exact death-rate for each year for each city has been carefully plotted out.* By this means the teaching of these death-rates cannot be mis-read.

Having made these reservations it is evident that in the American continent, if we may judge from experience of its chief cities, diphtheria is a very fatal *endemic* disease, which at intervals becomes *epidemically* and still more fatally prevalent.

Some useful indications may be gathered, if the experience of whole States is taken, as may be seen from the accompanying diagram constructed from a table given in

Dr. Baker's report to the State Board of Health for Michigan, 1892.

Fig. 12.

Fig. 12 has no marginal scale, but even without this, it is obvious that the total mass of and the variations in the mortality from diphtheria are enormously greater than in England. When allowance is made for the deficiencies in registration in some of these States, the difference becomes even more remarkable. The curves in the diagram relate to the years 1880–92, that of England being extended to include 1894. The scale in each of the curves is identical: and the striking difference in amount of mortality from diphtheria may be gathered not only by a glance at the curves, but by the fact that, taking Massachusetts and England as examples, the lowest death-rate from diphtheria *plus* croup in the former was 53 in 1891, and the highest 134 in 1880; while in England the lowest death-rate from diphtheria *plus* croup during the same period (1880–92) was 25 in 1880, and the highest 30 in 1887 and 1889, increasing to 39 per 100,000 in 1893. Thus the highest death-rate in England is not much more than half the lowest death-rate in Massachusetts.

CHAPTER II.

ENGLAND AND WALES.

Complete and fairly accurate statistics are available for England and Wales since 1839. In saying this, the fact that a certain but diminishing proportion of deaths from diphtheria have been returned as ulcerated throat, quinsy, croup, laryngitis, or membranous laryngitis, is not ignored. It must be remembered, however, that the increase of accuracy of certification is a gradual one, and thus the resulting transference to diphtheria of a comparatively small number of deaths, will not interfere with the substantial accuracy of any inferences that may be drawn from the English curves now to be considered, *these inferences being based on the general directions of these curves rather than upon the magnitude of the rise in any given year.*

The Registrar General's returns prior to 1860 class diphtheria or angina membranacea with scarlet fever. As, however, for several years prior to this, the former had been distinguished on the ticking sheets in the General Register Office, it is practicable to calculate a death-rate for diphtheria from 1855 onwards in England and Wales, and from 1859 for London, though almost certainly this does not represent all the diphtheria during these years. Judging, however, by the medical writings of the period, there was not, with the possible exception of 1847, a very large admixture of diphtheria and scarlet fever between the commencement of civil registration of deaths in July, 1837, and the great epidemic of diphtheria which invaded

England about 1855–57. The accompanying diagrams for England and for London confirm this view. Croup had been separately classified from 1838 onwards; and so had

Fig. 13.

laryngitis for a considerable portion of the period 1838-95. A glance at Fig. 13 will show that the transference of laryngitis to diphtheria would not materially affect the character of the curve. Almost the same remarks apply to croup. As diagnosis has improved, there has been a steady and gradual transference from croup to diphtheria.

A comparison of the curve for all England with that for London shows the same general outlines. Diphtheria was epidemically prevalent from 1858 to 1865, and a more recent epidemic reached its culmination in 1893, there having been a steady rise in the death-rate from this disease, especially in London, from 1887 onwards.

I had constructed a diagram showing the yearly death-rate from quinsy; but as this does not materially affect the curves, it has been omitted.

The average death-rate in England in successive groups of years is as follows :*—

ENGLAND AND WALES.

Annual Death-rate from Diphtheria and Croup per million persons living, in groups of years, 1858–94.

Period.	Diphtheria.	Croup.	Diphtheria *plus* Croup.
Three years, 1858–60	372·3	274·7	647·0
Five years, 1861–65	247·6	287·6	535·2
„ „ 1866–70	126·8	208·0	334·8
„ „ 1871–75	120·8	184·2	305·0
„ „ 1876–80	121·8	154·2	276·0
„ „ 1881–85	156·2	163·4	319·6
„ „ 1886–90	169·6	125·8	295·4
Four years, 1891–94	251·2	74·0	325·2

It is evident that whether the death-rate from diphtheria alone, or from diphtheria and croup together, be taken as the test, the early epidemic of 1858–65 was more

* For remarks on the defects inherent in average death-rates for epidemic diseases, see pp. 1 and 26.

severe and more fatal than the recent epidemic of 1891–94. Possibly, however, the full brunt of the recent epidemic has not yet been experienced in England as a whole, some districts not having been hitherto reached by the slowly travelling infection.

In London, the experience is somewhat different.

Death-rate in London from Diphtheria per million living.

Period.	Diphtheria.
Two years, 1859–60	458
Five ,, 1861–65	224
,, ,, 1866–70	133
,, ,, 1871–75	114
,, ,, 1876–80	130
,, ,, 1881–85	221
,, ,, 1886–90	298
Year 1891	340
,, 1892	462
,, 1893	760
,, 1894	625
,, 1895	529
,, 1896	606
,, 1897	507

Here it is evident that the later has been more severe and therefore presumably more extensive than the earlier epidemic. There are no actual data enabling one to make a comparison of cases as distinguished from deaths in the two great epidemics.

The history of the two great epidemics of diphtheria (1857–65 and 1888 onwards) will be considered later in special chapters (pp. 49 and 55).

Place.	Years of observation.	Diphtheria alone. Death-rate per 100,000.	
		Highest.	Lowest.
England and Wales .	1859–94	52 in 1859	9·4 in 1872
London	—	76 in 1893	8 in 1872

It will be convenient next to take the history of diphtheria in various English towns, so far as their records can be obtained, and from these to obtain a bird's-eye view of the progression of the disease in different parts of the country, similar to that attempted for the vaster territories embraced in the United States.

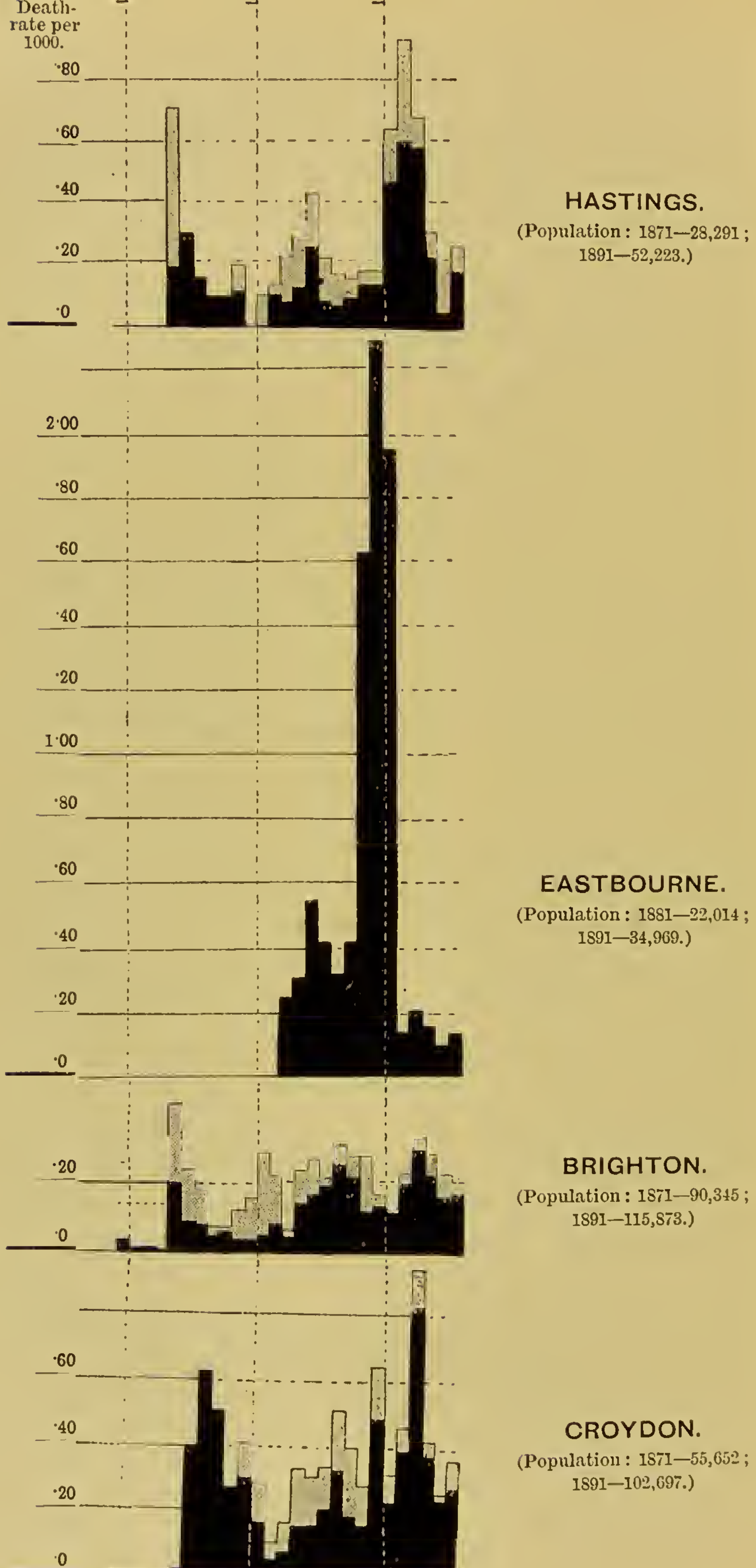
Southern Districts.

Hastings and Brighton had a small epidemic of diphtheria in 1883–4–5. In 1889–91 Eastbourne suffered from a severe epidemic, which merged into the earlier epidemic already mentioned. Hastings appeared to suffer, though to a less extent and a year later, from the same outbreak; and Brighton still later and to a less extent.

Croydon showed an epidemic culminating in 1877, possibly following on the slight rise shown in London in 1875. Both Brighton and Hastings had small epidemics, 1874–6; Portsmouth suffering to a smaller extent in the same year. The more recent course of diphtheria in Croydon corresponds very closely with that of London.

Portsmouth had no marked excess of diphtheria in 1860–62, and in fact no great epidemic until 1881–2, when it suffered very severely. Smaller outbreaks reached their maxima in 1886 and 1890, and since that year diphtheria has declined.

Southampton, during the periods for which records are obtainable (1873–96), has enjoyed a continuous comparative immunity from diphtheria.



Death-rate per 1000.
·80
·60
·40
·20
·0
HASTINGS.
(Population: 1871—28,291; 1891—52,223.)
2·00
·80
·60
·40
·20
1·00
·80
·60
·40
·20
·0
EASTBOURNE.
(Population: 1881—22,014; 1891—34,969.)
·20
·0
BRIGHTON.
(Population: 1871—90,345; 1891—115,873.)
·60
·40
·20
·0
CROYDON.
(Population: 1871—55,652; 1891—102,697.)

Fig. 14.

Place.	Years of observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria alone. Death-rate per 100,000.		Mean death-rate for entire period.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Hastings . .	1874–96	—	—	60 in 1892	*nil* in 1881	—	18
Eastbourne .	1883–96	—	—	229 in 1890	15 in 1894	—	42
Brighton . .	1870–96	—	—	30 in 1893	3 in 1879	—	13
Portsmouth .	1861–96	—	—	159 in 1881	4 in 1867	—	23
Southampton	1883–96	37 in 1889	6 in 1893	16 in 1888	1 in 1892	18	6
Croydon . .	1875–96	(95 in 1893)	(8 in 1882)	83 in 1893	1 in 1875	—	29

(See remarks on page 26.)

Western Districts.

Bristol has for a long period suffered very little from diphtheria. The early epidemic appears to have reached it in 1862, and continued, though never producing a high death-rate, for several years. For twenty years there was then very little diphtheria, and the recent epidemic, which commenced in 1891, has hitherto affected the city only to a minor extent (Fig. 15).

The curve for Cardiff is most irregular. The population of this town has quadrupled in the period embraced by the curve; and it appears likely that croup in these returns is not so closely related to or identical with diphtheria as in most other returns. The chief maxima occurred in 1884–87 and in 1892 (Fig. 15).

West Central and Midland Districts.

Birmingham had a small outbreak of diphtheria in 1871–72. The disease has remained endemic as in other towns of England, there being a steady mortality from it

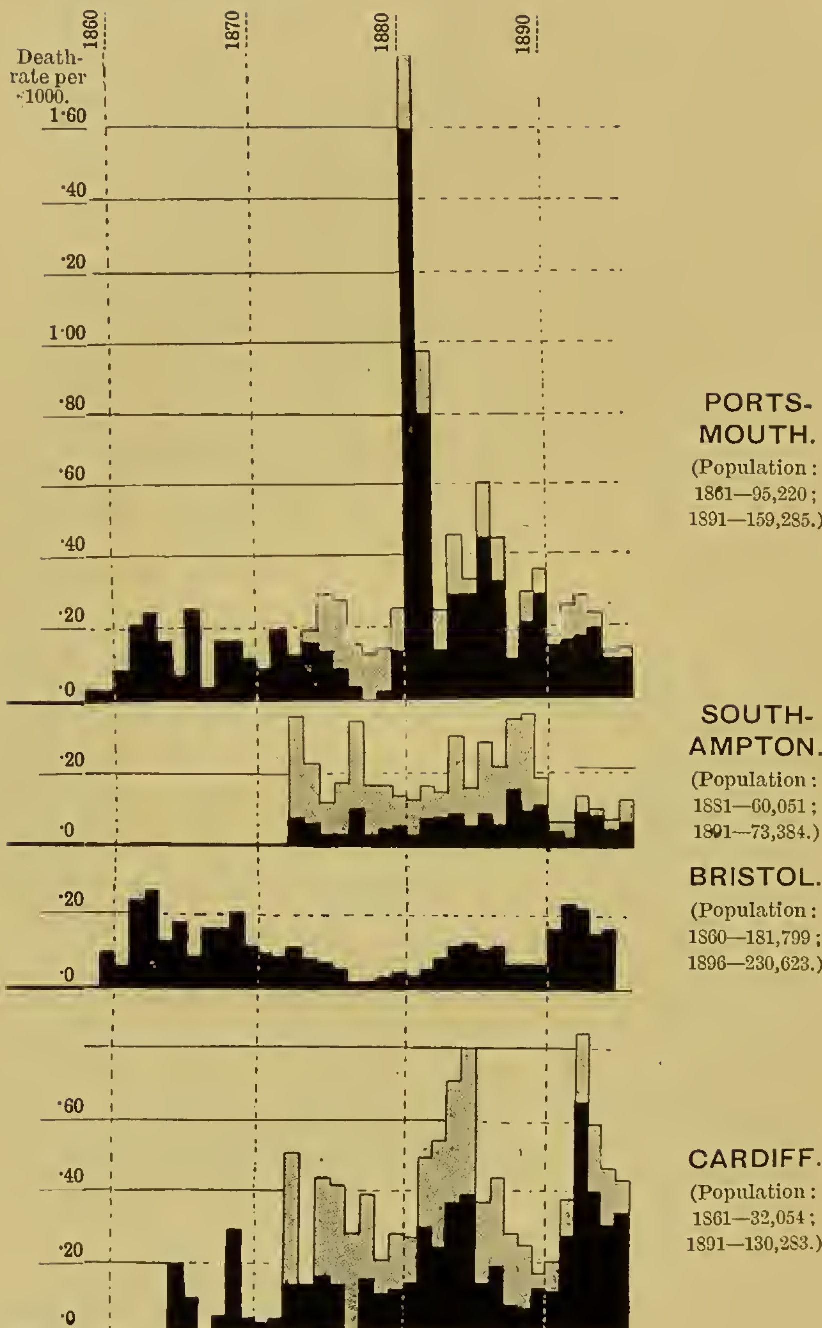

1860
1870
1880
1890
Death-rate per 1000.
1·60
·40
·20
1·00
·80
·60
·40
·20
·0
PORTS-MOUTH.
(Population:
1861—95,220;
1891—159,285.)
·20
·0
SOUTH-AMPTON.
(Population:
1881—60,051;
1891—73,384.)
·20
·0
BRISTOL.
(Population:
1860—181,799;
1896—230,623.)
·60
·40
·20
·0
CARDIFF.
(Population:
1861—32,054;
1891—130,283.)

Fig. 15.

on a small scale. In 1895–96 Birmingham suffered severely from epidemic diphtheria.

Wolverhampton had an epidemic of diphtheria culminating in 1885, and a much more severe epidemic in 1894–96, which may be connected with the epidemic starting a year later in Birmingham.

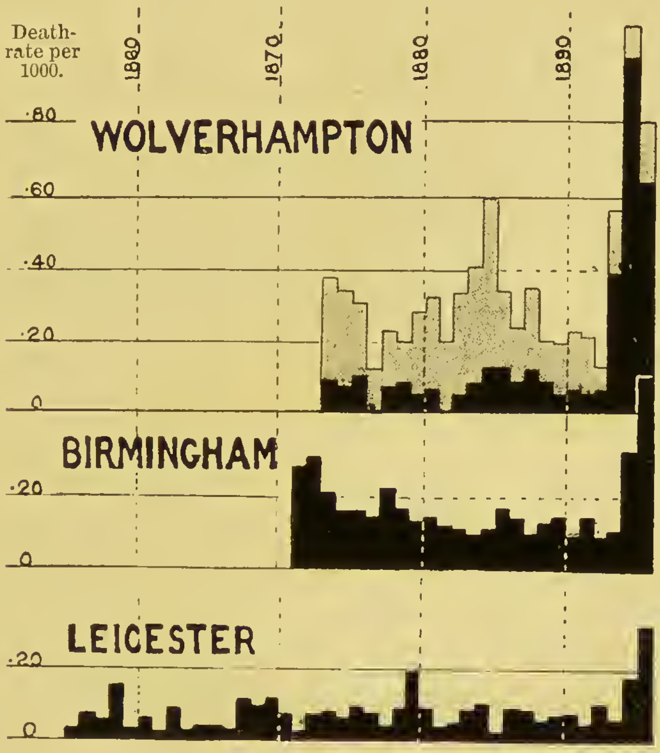


Fig. 16.

Leicester, as will be seen from the curve (Fig. 16), has suffered very little from diphtheria, the intermittent rises being of very small calibre. There is an appearance of an epidemic on a somewhat larger scale in 1896, the issue of which cannot yet be stated.*

* In 1897 the death-rate from diphtheria had increased from 31 in the preceding year to 36 per 100,000.

Place.	Years of observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria alone. Death-rate per 100,000.		Mean death-rate for the entire period.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Bristol . . .	1860–96	—	—	26 in 1863	2 in 1880	—	11
Cardiff . . .	1865–96	—	—	64 in 1893	0 in 1867	—	22
Birmingham .	1872–96	—	—	37 in 1895	9 in 1891	—	—
Wolverhampton	1874–96	122 in 1895	12 in 1877	98 in 1895	1 in 1882 & 1877	35	16
Leicester . . .	1856–96	—	—	31 in 1896	2 in 1872	—	9

(See remarks on page 26.)

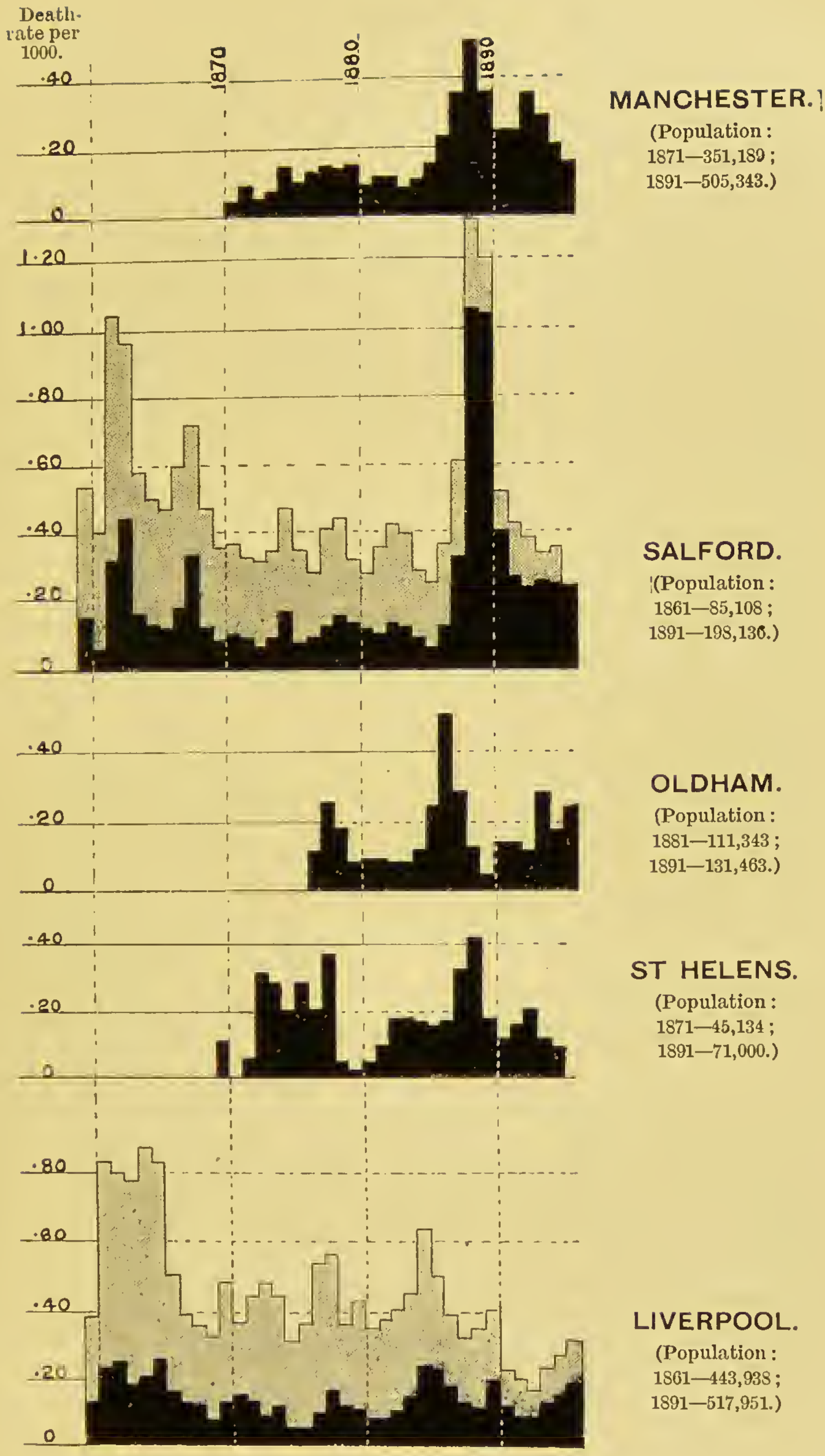
Lancashire.

This great industrial centre has a large number of towns within a short distance of each other, and a study of the prevalence and order of prevalence of diphtheria in these presents features of considerable interest.

Liverpool suffered somewhat severely in the 1860–65 epidemic, about to the same extent as London, more so if the portions of the curves relating to croup are included. Since then there is evidence of numerous small exacerbations of the disease, the greatest and most persistent being in 1884–87. Liverpool has hitherto suffered but little in the great English epidemic of the present decennium.

St. Helens, near Liverpool, has suffered much more than the latter from diphtheria. The excess in Liverpool in 1884–87 is represented by a larger excess in St. Helens in 1888–89; and by the still larger excess in Oldham in 1886–88.

We may next consider the curves for the twin cities of Manchester and Salford. It is easy to trace a gradation in time of incidence of the epidemics in Lancashire towns. Thus—



Death-rate per 1000.
1870
1880
1890
·40
·20
0
MANCHESTER.
(Population:
1871—351,189;
1891—505,343.)
1·20
1·00
·80
·60
·40
·20
0
SALFORD.
(Population:
1861—85,108;
1891—198,136.)
·40
·20
0
OLDHAM.
(Population:
1881—111,343;
1891—131,463.)
·40
·20
0
ST HELENS.
(Population:
1871—45,134;
1891—71,000.)
·80
·60
·40
·20
0
LIVERPOOL.
(Population:
1861—443,938;
1891—517,951.)

Fig. 17.

(*a*) The epidemic in Liverpool in 1884–87 caused a death-rate which only reached 25 per 100,000 in the maximum year 1885.

(*b*) The epidemic in Oldham in 1886–88 caused a death-rate of 50 per 100,000 in the maximum year 1887.

(*c*) The epidemic in Manchester in 1888–90 caused a death-rate of 51 per 100,000 in the maximum year 1889.

(*d*) The epidemic in Salford in 1889–90 caused a death-rate of 100 and 105 per 100,000 in these two years respectively.

There appears to be evidence, therefore, not only of *gradual spread* of the infection, but also of *increasing virulence,* as it passed through a population housed under conditions which are frequently the reverse of favourable.

The MANCHESTER epidemic, culminating in 1889, has been more persistent than the Salford epidemic, which culminated in a very high mortality in 1889–90, and appears to have "burnt itself out" with great rapidity.

SALFORD, like Liverpool, suffered severely in the epidemic 1859–64.

Place.	Years of Observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria alone. Death-rate per 100,000.		Mean Death-rate for the entire period.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Liverpool .	1860–96	87 in 1864	17 in 1893	26 in 1865	5 in 1875	43	14
St. Helens .	1870–95	—	—	42 in 1889	0 in 1871	—	18
Oldham . .	1877–95	—	—	50 in 1887	8 in 1883 & 1884	—	17
Manchester .	1871–96	—	—	51 in 1889	4 in 1871	—	18
Salford . .	1860–95	131 in 1889	24 in 1886	106 in 1889	6 in 1861 & 1873	67	32

(See remarks, page 26).

Yorkshire.

The Sheffield returns for diphtheria go back as far as 1859, and show a large epidemic of diphtheria in that year. After a remission in 1860, a second maximum was reached in 1862. This was followed by a gradual remission of the disease, which reached its minimum in 1884. In 1885 an excess of diphtheria on a small scale commenced, which still continues. The comparison of the early part of the Sheffield diagram with the corresponding parts for Liverpool and Salford shows that the remission of the early epidemic which occurred in 1860 in Sheffield, occurred in 1861 in Salford (Fig. 18).

Leeds and Bradford are neighbouring towns in the West Riding, as are also Halifax and Huddersfield. Hull, on the east coast, is comparatively remote from the other Yorkshire towns. We may contrast the very small epidemic in Hull in 1883–84 with the slightly greater epidemic in Leeds in the same year, the still slightly greater epidemic in Halifax in 1886, the much more severe epidemic in Huddersfield in 1887, and the more protracted epidemic in Sheffield, which culminated in 1889–92. Bradford appears to have almost entirely escaped any epidemic prevalence of diphtheria during 1881–90, or in any other year. Leeds and Hull come next in order of relative exemption, while Sheffield shows a considerable amount of endemic diphtheria.

Place.	Years of observation.	Diphtheria. Death-rate per 100,000.		Mean death-rate for the entire period from Diphtheria.
		Highest.	Lowest.	
Sheffield . .	1859-96	99 in 1859	3 in 1886	15
Leeds . . .	1872-96	19 in 1894	3 in 1887	10*
Bradford . .	1871-96	14 in 1878	1 in 1873	7*
Halifax . .	1872-96	25 in 1893	3 in 1884	12*
Huddersfield	1879-95	46 in 1887	3 in 1893	12*
Hull . . .	1870-96	23 in 1896	2 in 1896	7*

* See foot note on p. 25.

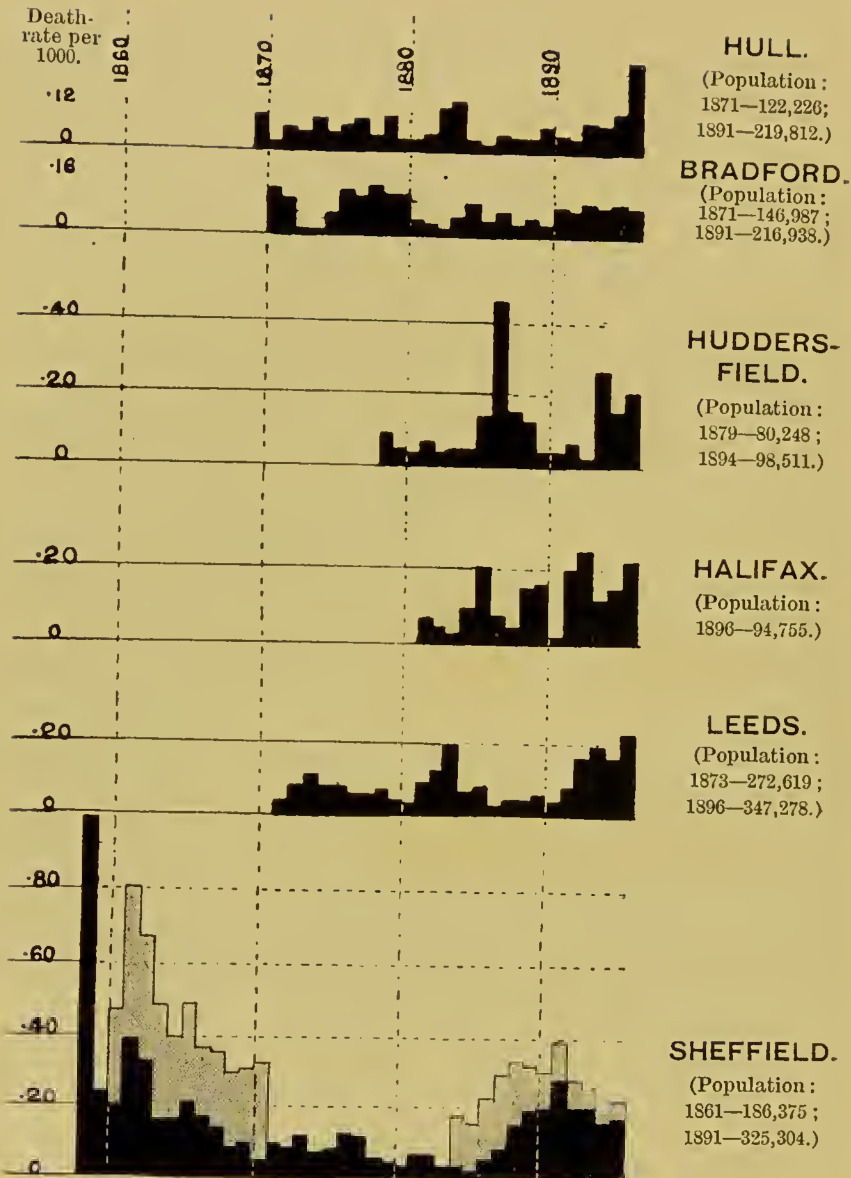


Fig. 18.

NORTHUMBERLAND.

The curves for NEWCASTLE-UPON-TYNE and SOUTH SHIELDS resemble each other in shape and time incidence. There has been no great epidemic; but it is evident that the amount of diphtheria increased in both towns from the middle of the last decennium onwards, and that these towns now show a declining amount of diphtheria, without the amount ever having been alarming. Newcastle has a larger amount endemically present than South Shields.

Place.	Years of observation.	Diphtheria. Death-rate per 100,000.		Mean death-rate per 100,000 for the entire period.
		Highest.	Lowest.	
Newcastle-upon-Tyne.	1870–96	27 in 1890	3 in 1879	12
South Shields	1871–95	29 in 1891	2 in 1893	11

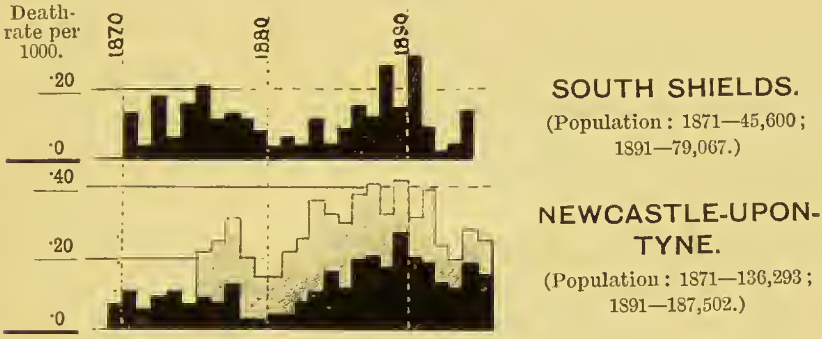


Fig. 19.

CHAPTER III.

SCOTLAND AND IRELAND.

A GLANCE at the Scottish returns (Fig. 20 and 21) shows some striking contrasts with those for English towns. There is a greater mass of diphtheria in the Scotch towns than in the English. The disease is more distinctively and more extensively endemic than in England.

The average death-rate from diphtheria for the entire period 1858–95 is much higher than that of most English towns. This is especially true for Glasgow, Greenock, and Edinburgh. All the Scottish cities whose records extend sufficiently far back, appear to have suffered from the early epidemic from 1859 onwards. This reached Aberdeen in 1859, Greenock in 1860, and only reached its maximum in the neighbouring city of Glasgow in 1862–63. Perth suffered to an exceptional extent in 1862; while Edinburgh, like Glasgow, had its maximum incidence in 1863.

Edinburgh had an epidemic in 1870–71, while a similar epidemic culminated in Greenock and Glasgow in 1873, in Dundee in 1872–73, in Aberdeen in 1872, and in Perth not until 1876. Most of the Scotch towns have hitherto not suffered, or but little, from the epidemic, which has been so widespread in England from 1888 onwards. The chief exception to this rule is Kilmarnock.

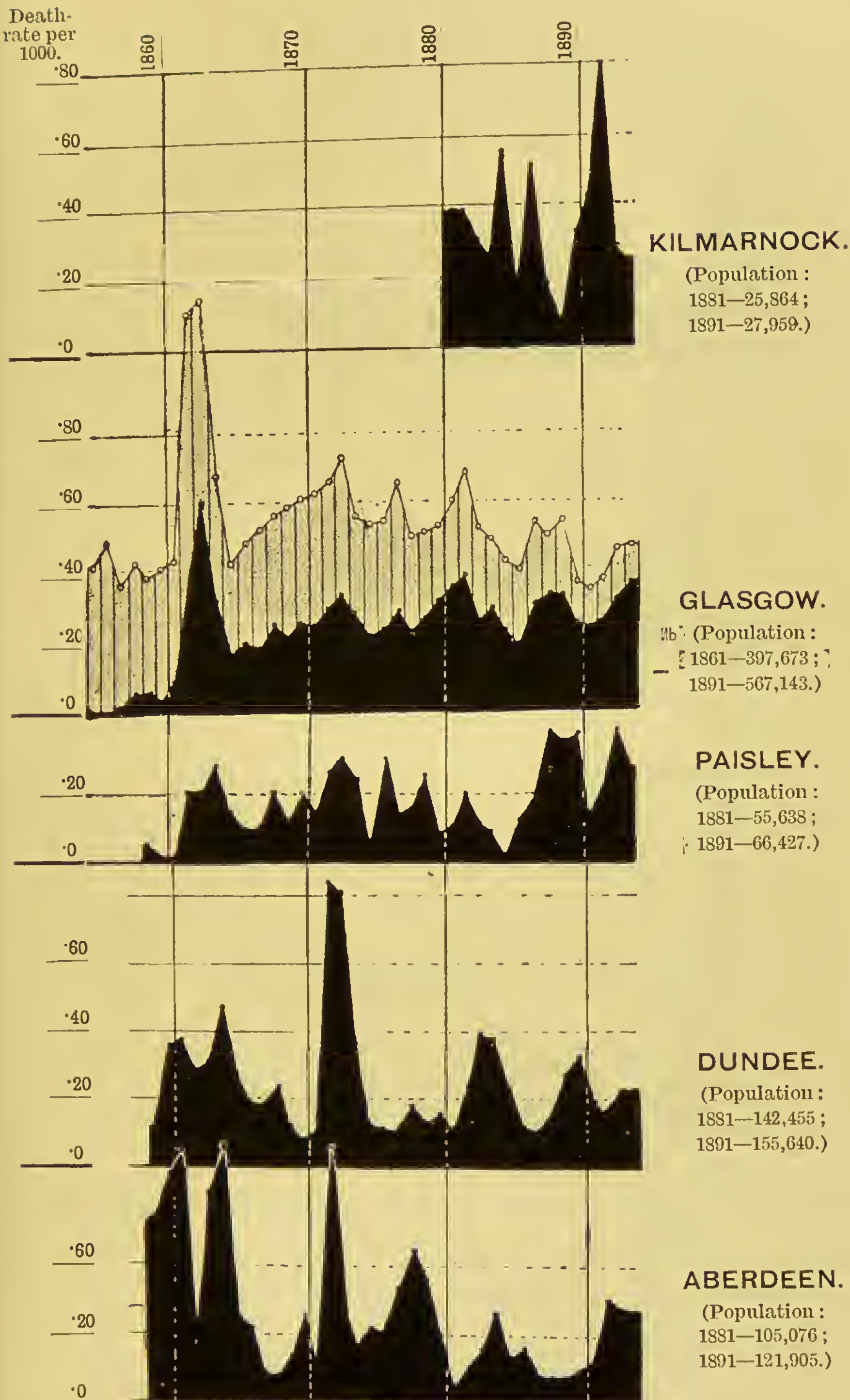

Death-rate per 1000.
1860
1870
1880
1890
·80
·60
·40
·20
·0
KILMARNOCK.
(Population :
1881—25,864 ;
1891—27,959.)
GLASGOW.
(Population :
1861—397,673 ;
1891—567,143.)
PAISLEY.
(Population :
1881—55,638 ;
1891—66,427.)
DUNDEE.
(Population :
1881—142,455 ;
1891—155,640.)
ABERDEEN.
(Population :
1881—105,076 ;
1891—121,905.)

Fig. 20.

Fig. 21.

Note.—The Scottish and Irish curves terminate in angular points instead of in horizontal lines. These diagrams had been completed before the columnar shape of diagrams was finally chosen, but it was not thought necessary to reconstruct the diagrams already completed.

Place.	Years of observation.	Diphtheria. Death-rate per 100,000.	
		Highest.	Lowest.
Kilmarnock . .	1873–94	80 in 1892	7 in 1889
Paisley	1859–94	39 in 1888 & 1893	2 in 1860
Glasgow	1859–94	60 in 1863	3 in 1860
Greenock . . .	1859–94	87 in 1860	15 in 1876
Edinburgh . . .	1859–94	80 in 1871	6 in 1861
Perth	1859–94	266 in 1863	0 in 1859
Dundee	1859–94	85 in 1872	9 in 1870
Aberdeen . . .	1859–94	75 in 1864	8 in 1877 & 79

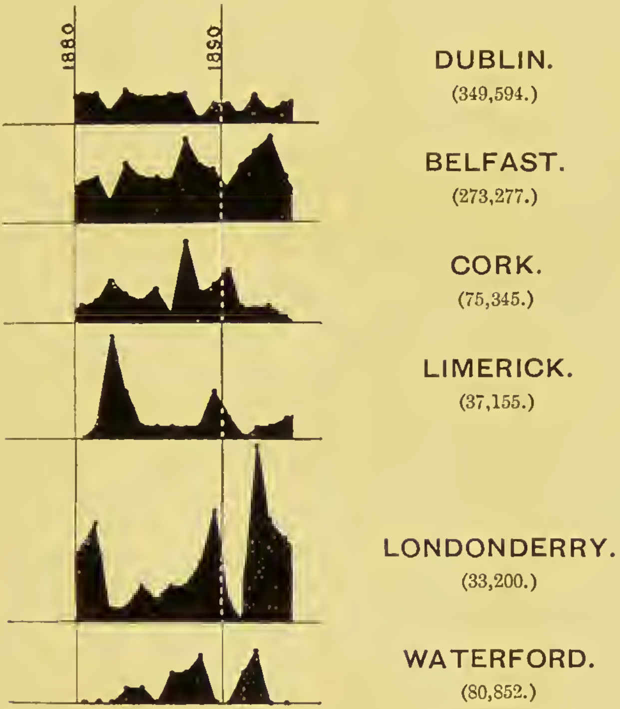


Fig. 22.

NOTE.—The populations given within the brackets are those of the census enumeration, 1891. The scale of the diagram is the same as that of the preceding diagrams.

IRELAND.

Ireland is a sparsely populated country; and on the hypothesis that diphtheria is conveyed chiefly by personal infection, it is not surprising to find that its amount in

Ireland is small. Since 1881, when returns became first available, there has been a small epidemic in Londonderry in 1882, and in Limerick in 1883. Londonderry had a rather larger epidemic in 1889, followed by a still higher rise, after an interval of two years, in 1883. Dublin has throughout the whole period (1881–95) remained remarkably free from this disease. The Belfast curve shows a larger mass of the disease than any other Irish town, though less than most Scotch and many English towns.

Place.	Years of observation.	Diphtheria. Death-rate per 100,000.	
		Highest.	Lowest.
Dublin	1881–95	10 in 1885	2 in 1889
Belfast	1881–95	24 in 1888 & 1894	6 in 1883
Cork	1881–95	23 in 1888	2 in 1887 & 1895
Limerick . . .	1881–95	29 in 1883	3 several years
Londonderry . .	1881–95	51 in 1893	3 in 1883
Waterford . . .	1881–95	15 in 1893	0 several years

CHAPTER IV.

THE HISTORY OF THE GREAT EPIDEMIC OF DIPHTHERIA IN LONDON IN THE FIFTH AND SIXTH DECADE OF THE NINETEENTH CENTURY.

In 1847 the London curve (Fig 13) shows a striking rise in the death-rate from croup, it being 154 per cent. higher than in the preceding year. Does this mean an increase of laryngeal diphtheria, or of some other disease masquerading under the name of croup? The curve for the whole of England does not help, as the records for 1847 are absent. The historical summary (page 116) shows that diphtheria was prevalent in London and elsewhere in 1848–49. The sparsity of recorded cases by no means proves that this unrecognised disease was not prevalent in 1847. On the other hand, 1847 was a great influenza year, and it may be that the sudden rise in deaths from croup was really due to inflammatory laryngitis secondary to influenza. Dr. Peacock's historical account,* however, makes it probable that there was considerable true diphtheria. He says: "There was also, during the period of the influenza, a great increase in the number of deaths from the various descriptions of eruptive fever, small-pox, measles, and scarlet fever, as likewise from hooping cough, etc. . . . *with affections of the fauces and larynx*" (p. 353). On a later page (p. 366) Dr. Peacock says: "From the tables of mortality, it will be seen that the deaths from croup, quinsy and laryngitis were during the epidemic much

* "Influenza: an History Survey," Dr. Symes Thompson, 1890, p. 355.

E

more numerous than usual." We are, therefore, I think justified in regarding 1847 as a year of epidemicity of diphtheria. It is not without significance that the present epidemic of diphtheria in London has coincided in part with the years of reappearance of epidemic influenza.

Until 1859, the metropolitan death-statistics do not tabulate diphtheria separately from scarlet fever. So far as official returns are concerned, it is therefore impracticable to state the amount of diphtheria, or to form any idea as to the occurrence of epidemic peaks of this disease prior to that year. A careful study of (*a*) the figures for the whole of England and Wales, and (*b*) the figures for London for diseases closely allied to, and liable to be confounded with diphtheria, partially serves to fill up the hiatus in our knowledge.

The curve for England and Wales (Fig. 13) appears to give a result more nearly approximating the truth for London, than the metropolitan curve in the same illustration. This curve indicates that in 1858–59 diphtheria was already epidemically present in a most fatal form, although it is fairly certain that the returns for the whole of England do not tell the whole truth for the early years 1855–57. That this is so, is indicated by the following official figures, which serve to show the progress of the English epidemic in the early years, and to give some idea of the extent of transference of deaths by alterations of nomenclature.

Year.	Deaths in England and Wales from			
	Cynanche Maligna.	Diphtheria.	Quinsy.	Scarlet Fever.
1855	199	186	371	17,314
1856	374	229	413	14,160
1857	1,273	310	485	14,229
1858	1,770	4,836	623	30,317

The difficulty is increased by the fact that scarlet fever in a very fatal form was epidemic during the same years, and much of the diphtheria was regarded by practitioners, in whose experience diphtheria was a totally new disease, as scarlatina anginosa.

A careful study of the metropolitan figures themselves shows that the epidemic of diphtheria was present before 1859, the first year shown on the curve in Fig. 13.

In the following table I have calculated the annual death-rate from diphtheria, croup, quinsy, and laryngitis in London from 1839 to 1868.

Year.	Annual Death-rate per 1,000 living from			
	Diphtheria.	Croup.	Laryngitis.	Quinsy.
1839	No entry	·18	·01	·05
1840	"	·21	·01	·04
1841	"	·21	·01	·04
1842	"	·24	·01	·04
1843	"	·11	·01	·03
1844	"	·20	·03	·05
1845	"	·17	·04	·03
1846	"	·13	·10	·04
1847	"	·33	·10	·04
1848	"	·13	·08	·04
1849	"	·14	·08	·04
1850	"	·13	·08	·03
1851	"	·13	·08	·03
1852	"	·14	·08	·02
1853	"	·15	·10	·02
1854	"	·19	·13	·03
1855	"	·21	·11	·04
1856	"	·22	·11	·03
1857	"	·17	·12	·03
1858	"	·21	·12	·04
1859	·284	·15	·10	·03
1860	·174	·17	·10	·02
1861	·239	·30	·14	·04
1862	·255	·33	·15	·03
1863	·275	·32	·13	·03
1864	·207	·30	·13	·03
1865	·144	·25	·11	·02
1866	·152	·23	·10	·02
1867	·145	·24	·11	·01
1868	·158	·23	·11	·01
1869	·107	·28	·13	·01

It will be seen that in 1855 the death-rate from croup was 53 per cent, and in 1855 it was 60 per cent., above the mean death-rate from this disease in the years 1848–53. A similar increase in laryngitis occurred. Furthermore, the recorded death-rate from diphtheria in 1859 was higher than in any of the epidemic years 1861–64, when the disease had become more generally recognised as such. It is highly improbable, therefore, that the high death-rate of 1859 represented a newly imported disease. We may conclude, with much more probability, that it had been epidemic for a year or two previously, although imperfectly recognised. Collateral evidence points in the same direction. Thus in the *Weekly Return of Diseases in the Metropolis* for the week ending Saturday, October 31st, 1857, the following remarks occur : * "In future numbers of the *Weekly Return* a separate column will be allotted to new cases of diphthèrite. . . . At the present time *diphthèrite* threatens to demand more attention in this country ; for apparently it is to its prevalence, as a cause of death in several districts, that various registrars' notes in the late quarterly report of the Registrar-General refer. . . . There is reason to believe that cases are also occurring within the limits of the metropolis ; sometimes recognised in their true nature, and called either diphthèrite or Boulogne fever ; sometimes, perhaps, mistaken for true croup, or for the throat-inflammation of scarlet fever, or for some other disease."

Dr. E. Greenhow's work "On Diphtheria"† contains confirmatory evidence. He states (p. 72) : "Sore throats, which were remarkably frequent during the years 1857, 1858, and 1859, continue to prevail ‡ (March 1860)." He

* Quoted by Mr. (now Sir John) Simon, in his Second Report to the Privy Council, 1859. See p. 13, vol. ii., *Public Health Reports*, by J. Simon, edited by Dr. Seaton.

† Jno. W. Parker & Son, Strand, 1860. ‡ *i.e.* in London.

also describes a number of cases occurring during these years, which were obviously true diphtheria. On page 80 of the same work, he remarks: "In a sporadic form, or in the form of very small groups confined to a limited district, diphtheria has probably never been absent from this country." The value of this remark is somewhat diminished by the following remark, with which it is associated: "In this respect it resembles cholera, the other novel epidemic of the present century."

Mr. Netten Radcliffe in a paper, "On the Recent Epidemic of Diphtheria" (vol. i., part iii., p. 328, *Transactions of the Epidemiological Society*), says: "The order of epidemic manifestation of the disease, in point of time, in the different districts of the kingdom, after 1855, was,—

In 1856 (1) The West-Midland Counties.
(2) The Eastern Counties.
(3) The South-Eastern Counties.
(4) The North-Midland Counties.
In 1857 (5) The South-Midland.
(6) The North-Western.
(7) Yorkshire.
(8) The Metropolis.
In 1858 (9) The South-Western Counties.
In 1859 (10) The Northern Counties, Monmouth, and Wales."

The following further sentences may be quoted from Mr. Ratcliffe's important paper (*op. cit.* p. 334), as they throw considerable incidental light upon diphtheria in London.

"If the mortality returns for the years 1840-59 be examined, it is found that scarlet fever underwent a prodigious increase in 1858, and prevailed in that year to a greater extent than in any previous year of the nineteen.

(2) That the mortality from *croup* advanced year by year from 1854; that, in fact, the disease was epidemic in 1856, '57, '58, and '59, the epidemic culminating in 1858. The mortality from the disease also was prodigiously above the average of preceding years; increasing from 3,660 in 1853 to 6,220 in 1858. (3) That the mortality from thrush also was greatly in excess in 1858 and 1859, though not to the same extent as in 1848 and 1852. (4) That the mortality from quinsy was in excess in 1857 and 1858, in the latter year attaining a higher point than in any previous year. (5) That the mortality from noma had undergone a remarkable increase in 1855, '56, '57, and '59, culminating in 1857. (6) That the mortality from laryngitis had undergone a steady development from 762 in 1847, to no less an extent than 1,439 in 1858. In fact, it is not too much to say that *all the affections allied to diphtheria prevailed epidemically contemporaneously with diphtheria.*"

If in the last sentence, we substitute for "affections allied to diphtheria," the alternative words, "affections with which diphtheria is liable to be confused," we are justified in the conclusion that in London diphtheria was steadily increasing in amount from 1854 onwards, being widely epidemic early in 1857.

The question of transference, since 1881, to diphtheria of deaths which were formerly ascribed to other throat affections, is discussed in an interesting paper by Dr. J. F. J. Sykes.*

* *Public Health*, vol. vi., p. 331.

CHAPTER V.

THE HISTORY OF THE EPIDEMIC OF DIPHTHERIA IN LONDON, 1888–96, AND ITS BEARING UPON THE METHOD OF SPREAD OF THE DISEASE.

THE area of London (Registration area) is 121 square miles. At the census of 1891, there were within this area 544,947 inhabited houses, containing an average of 7·7 persons to a house. Its population at the middle of 1897 is estimated to have increased to 4,463,169, the enumerated population in April, 1891 being 4,211,743.

A consideration of the mode of spread of diphtheria in this vast province of houses, as evidenced by official statistics for the several districts composing the metropolis, must throw light on the general problem of the mode of progression of this disease. A glance at Fig. 13 shows that in London as a whole, diphtheria had been increasing fairly steadily, the total volume of the disease (as indicated by deaths) increasing year by year with very slight interruptions until the maximum was reached in the year 1893.

The annual summary of the English Registrar-General for 1895 contains, on page 9, a table giving the deaths from diphtheria in the Metropolitan Sanitary Area in the nine years 1887 to 1895, after distribution of deaths occurring in public institutions. From this table, supplemented by later returns for 1896, the death-rates per 100,000 of population have been calculated and plotted out on the diagrams in Figs. 23 and 24. It must be noted that the census population is assumed in each case to hold good throughout the ten years. This will have produced some exaggeration of the latter half of the curves, but even assuming that the exaggeration is not to the same extent in the different diagrams, this is of little consequence, as it is the directions of the curves and their general shape with which we are concerned rather than the actual height in any given year.

The western parish of *Paddington* had a first epidemic in 1888, a second in 1894. In the next parish, *Kensington*, the first epidemic did not reach its maximum until the epidemic was subsiding in Paddington. *Hammersmith*, further west, lagged two years behind Paddington and Kensington, and at the end of the curve had not experienced an epidemic "relapse," while *Fulham*, to the south-west,* escaped for several years, did not suffer severely until 1893, still more severely in 1894.

Returning eastwards along the north bank of the Thames, *Chelsea* was a year behind Kensington, two behind Paddington. It had a smart second epidemic in 1896.† *St. George's, Hanover Square*, abutting on Paddington, had its maximum in the same year as the latter, as did also the *Westminster* parishes, though somewhat irregularly.

Proceeding northward, *St. Marylebone*, the next parish on the east of Paddington, scarcely experienced the first ‡ epidemic; but the second ‡ culminated in 1893, a year earlier than in Paddington.

* The significance of the curves is better understood if they are studied in conjunction with a district map of London.

† The rationale of the two epidemics of diphtheria in Chelsea is explained by Dr. Louis Parkes, in an interesting paper (*Epidemiological Society's Transactions*, vol. xvi.). The epidemic of 1890 occurred in its outlying district of Kensal Town, allied geographically to Kensington and Paddington, the late epidemic in the home district.

‡ I am obliged to speak of the "first" and the "second" epidemics. They are really part of the one great London epidemic, which did not exhaust itself in a single onslaught.

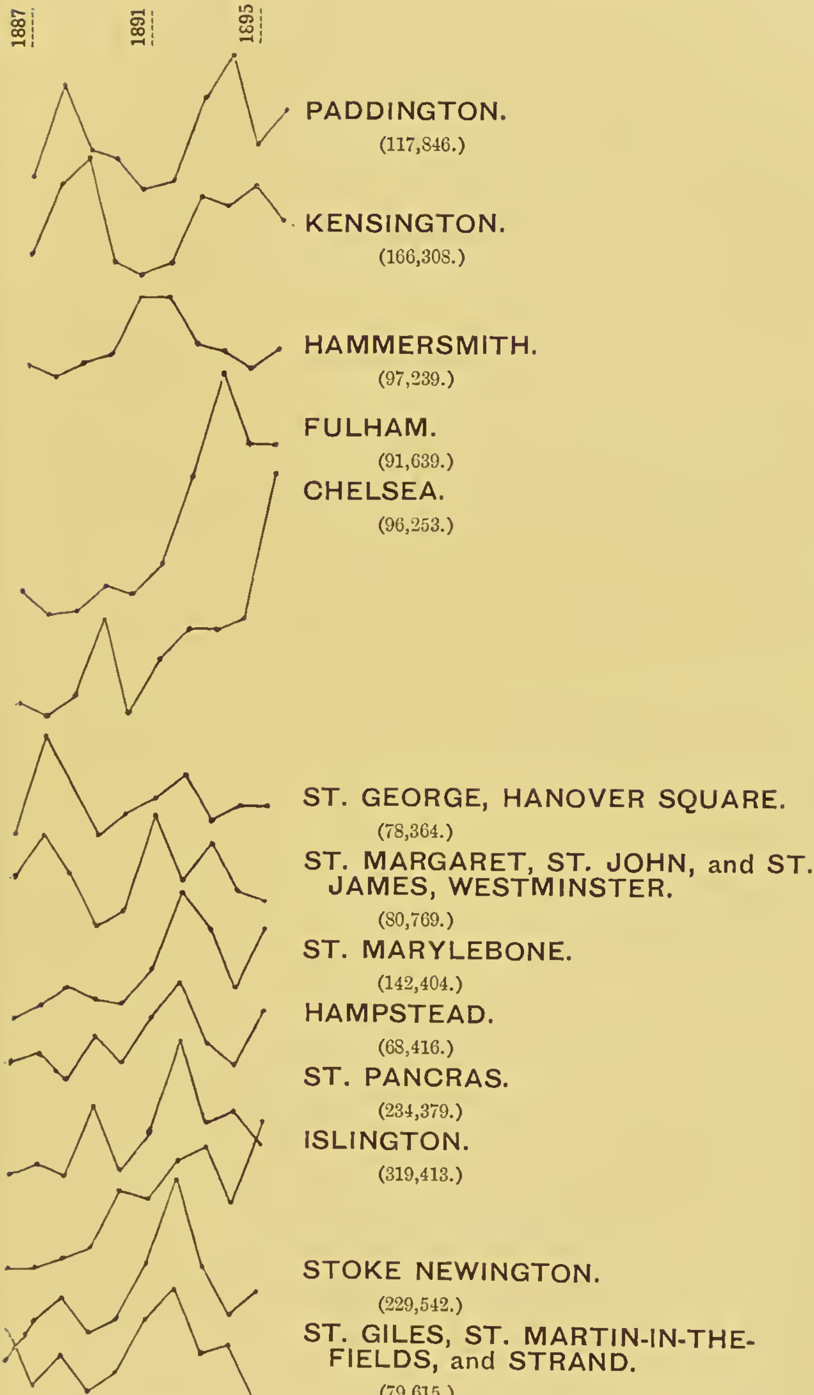


Fig. 23.

(The figures in brackets are the population of each district or parish at the census in 1891.)

The experience of *Hampstead* and of *St. Pancras* is identical with that of St. Marylebone, except that the first epidemic appeared distinctly in their experience.

Islington, to to the north-east of St. Pancras, lagged a year behind in its epidemic experience, while Stoke Newington, like St. Pancras, had its maximum in 1893; so also did the more central district of the *Strand.*

Coming still nearer the centre of London, and travelling thence eastward, we find that *Holborn* and the *City* escaped the first epidemic, the City maximum occurring in 1892, the Holborn maximum in 1893.

Shoreditch, to the north-east of the City, had the same time-incidence of the disease as Holborn and Clerkenwell abutting on it.

Bethnal Green had its first epidemic, culminating in 1890, and a much larger epidemic "relapse," culminating in 1892–93. *Whitechapel* had a somewhat similar experience, as also Limehouse and Poplar, as regards the 1893 maximum, but with a varying incidence of the first epidemic.

Crossing the river Thames, the *Southwark* parishes and *Newington* show a first epidemic in 1888 or 1889, and a later epidemic with a maximum in 1893–94. *Bermondsey* had a similar experience, and so also had Lambeth.

In *Battersea* and *Wandsworth* there was comparatively little diphtheria before the sudden maximum in 1893.

Camberwell was a year behind Wandsworth; and the outlying districts of *Greenwich* and *Lee,* although commencing their epidemics in 1893, only reached the maximum in 1895. The experience of *Lewisham* was very similar to that of Wandsworth, but in both these districts there was a second exacerbation of the disease in 1896.

The curves thus briefly described are of great interest.

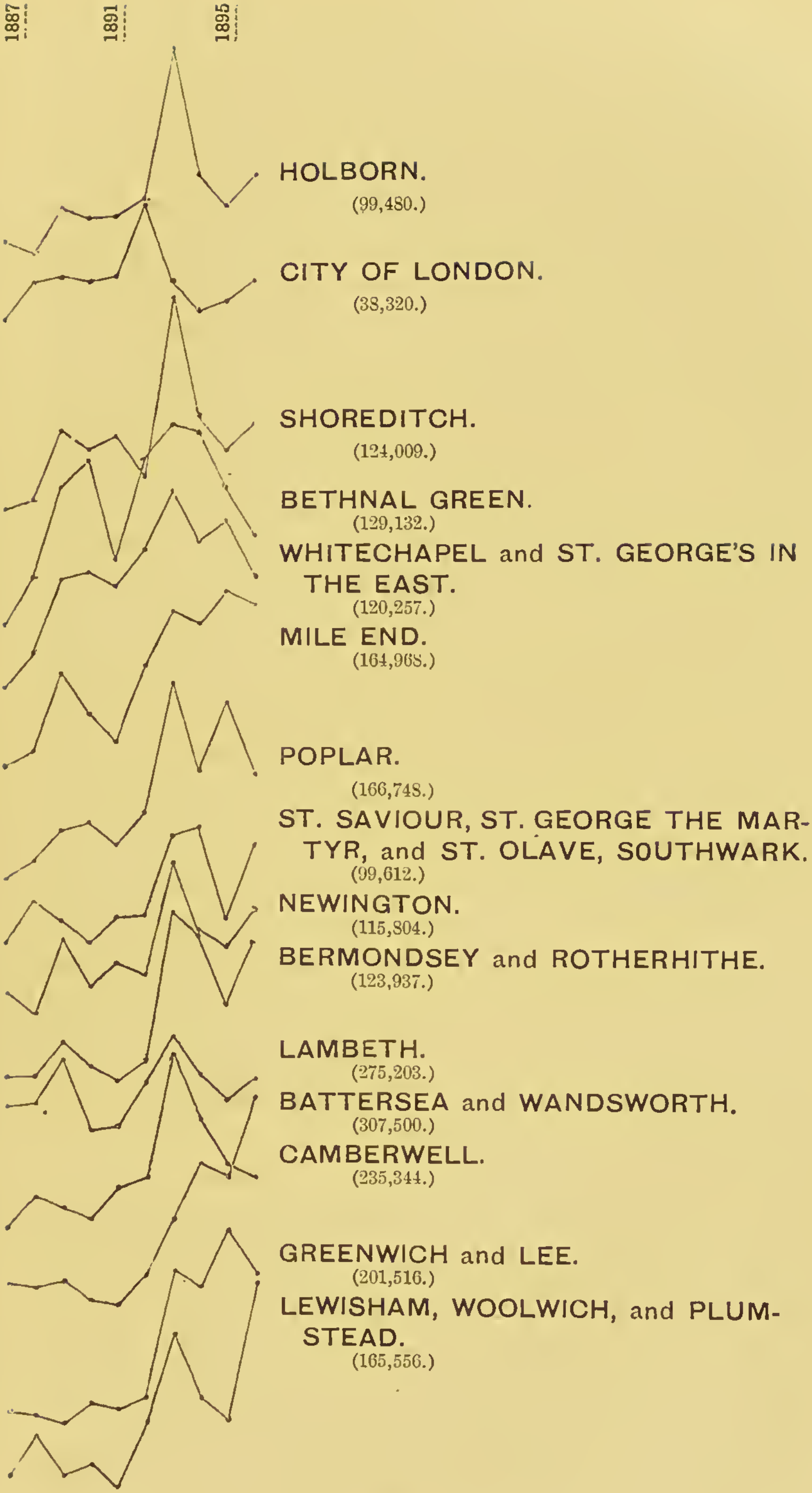

1887
1891
1895
HOLBORN.
(99,480.)
CITY OF LONDON.
(38,320.)
SHOREDITCH.
(124,009.)
BETHNAL GREEN.
(129,132.)
WHITECHAPEL and ST. GEORGE'S IN THE EAST.
(120,257.)
MILE END.
(164,968.)
POPLAR.
(166,748.)
ST. SAVIOUR, ST. GEORGE THE MARTYR, and ST. OLAVE, SOUTHWARK.
(99,612.)
NEWINGTON.
(115,804.)
BERMONDSEY and ROTHERHITHE.
(123,937.)
LAMBETH.
(275,203.)
BATTERSEA and WANDSWORTH.
(307,500.)
CAMBERWELL.
(235,344.)
GREENWICH and LEE.
(201,516.)
LEWISHAM, WOOLWICH, and PLUMSTEAD.
(165,556.)

Fig. 24.

They clearly show that while one part of the metropolis was suffering severely from diphtheria, others were relatively exempt; and that the latter in their turn suffered from the same plague. This is seen over and over again in contiguous parishes, and it is impossible to resist the conclusion that in diphtheria we have to deal with a disease which creeps slowly from place to place, in which months or even several years may elapse before it takes firm root and begins actively to propagate itself. It cannot be imagined that climatic differences between the various parishes of London can account for the erratic time-incidence, of the outbreak of diphtheria in these parishes. The different parts of London differ but slightly in amount of sunshine, rainfall, temperature, or humidity of air. We are hemmed in to the conclusion that the differences of time-incidence of the epidemic in the various parishes of London are determined chiefly, if not solely, by the opportunities for free personal intercommunication and infection. This does not exclude the possible operation of factors favouring in certain districts an exceptionally severe development of the disease, or permitting its retention in the district for an exceptionally long period. Nor, on the other hand, does it exclude the operation of some wider causes which, co-operating with personal infection, provoked the great London epidemic from 1888 onwards.

A further point is clear from the above curves. In the first outburst of the disease it does not exhaust its local possibilities. A second outbreak is shown in at least fifteen out of the twenty-eight curves contained in Figs. 23 and 24. It is instructive to compare in this respect the curves for large towns remote from other towns, in which such epidemic "relapses" are not so usual. That they should occur in the different parishes of London is not surprising, when we remember that each parish is a part of the great province of London, and that when the disease has spent itself at a particular focus, there are abundant opportunities for its rejuvenescence by fresh importation from foci in other districts.

In the present chapter diphtheria in London has been discussed as though personal infection were the sole factor concerned in its spread. But why should personal infection be so potent in producing an epidemic in certain years, while at other periods, with the same opportunities of personal infection, no epidemic is caused? The discussion of this wider problem is contained in Chapters XVI and XVII.

CHAPTER VI.

FRANCE, ITALY, HOLLAND, AND BELGIUM.

Paris.—The vital statistics for Paris only extend back to 1865, while those for provincial towns of France are only available since 1886.

We find from an historical study of diphtheria, summarised on pages 110 to 126, that Paris has during the last two centuries been a favourite home of this disease. It is not surprising, therefore, that the curve for this city since 1865 shows a large amount of diphtheria endemically present. The French and Italian returns hereafter given, and many of the German and other continental returns, do not differentiate between diphtheria and croup, but class them together as one disease.

Dr. J. Bertillon, the head of the Municipal Statistical Office in Paris, in a letter to the author, dated January 30th, 1897, says: "Nous, n'avons jamais fait en France de distinction entre la diphthérie et le croup, que nous regardons comme deux formes de la même maladie."

The Parisian curve shows a steadily increasing prevalence of diphtheria plus croup from 1872 * until the acme is attained in 1877, then occurs a slow and fairly steady decline to a minimum in 1895–96. The contrast with the London curve is sufficiently striking. When the London curve was at its minimum, that for Paris was very high; and the London curve rose as that for Paris

* There is some doubt as to the accuracy of this portion of the curve, the number living in Paris during the Franco-German war, and particularly during the siege of Paris and the reign of the Commune, being doubtful.

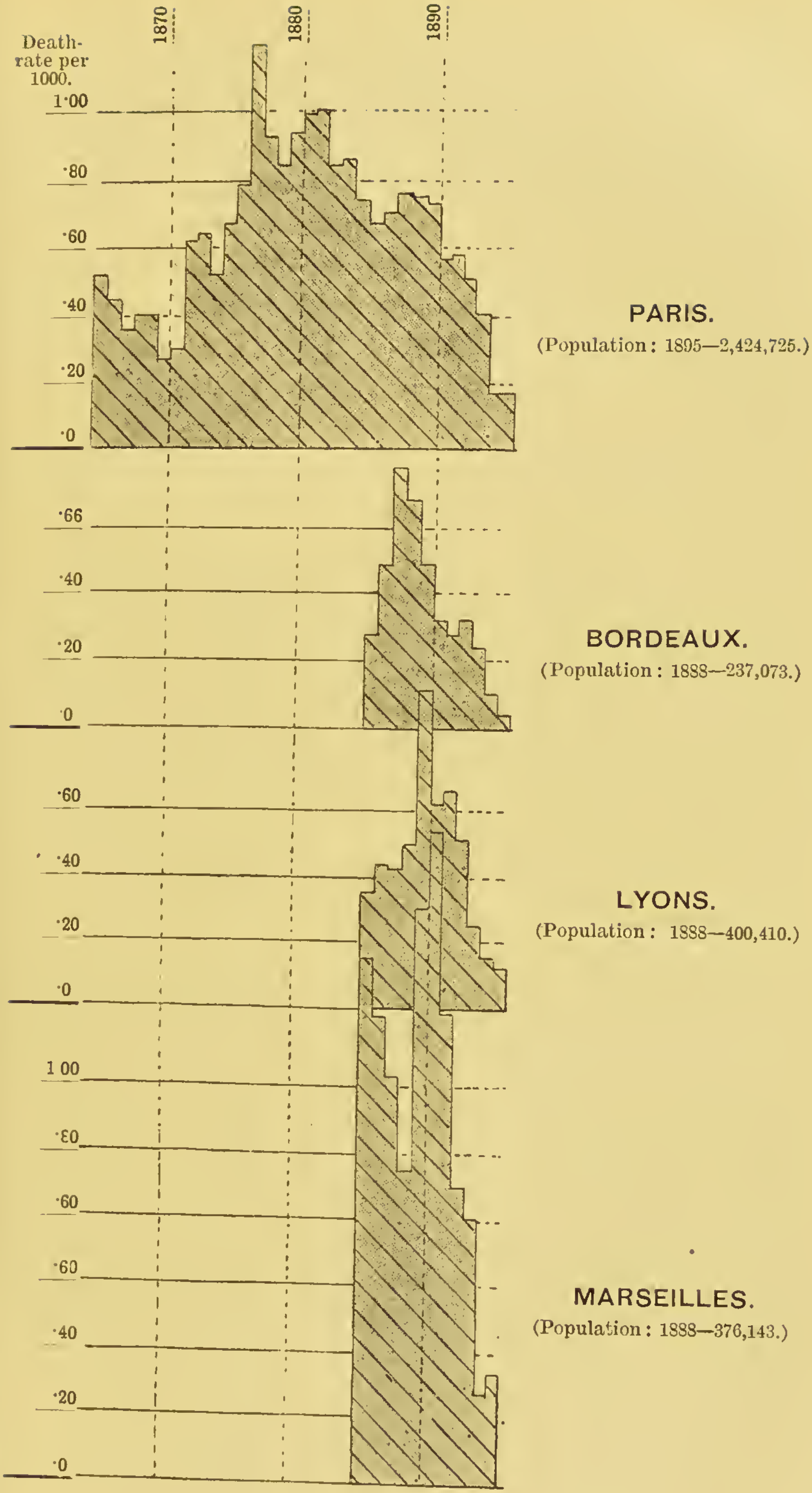

1870
1880
1890
Death-rate per 1000.
1·00
·80
·60
·40
·20
·0
PARIS.
(Population: 1895—2,424,725.)
·66
·40
·20
·0
BORDEAUX.
(Population: 1888—237,073.)
·60
·40
·20
·0
LYONS.
(Population: 1888—400,410.)
1 00
·80
·60
·60
·40
·20
·0
MARSEILLES.
(Population: 1888—376,143.)

Fig. 25.

fell. With regard to the minimum in 1895–96, we have to note the disturbing influence on mortality returns of the new treatment of diphtheria by antitoxic serum; and on this point I may again quote a remark made by M. Bertillon in the letter above-mentioned: "Vous remarquerez sans doute combien la diphthérie est devenue rarement mortelle en 1895 et 1896. Cela est dû sans aucun doute à l'usage très repandu de serum de l'Institut Pasteur."

I am, however, strongly of opinion that although a portion of the decreased mortality from diphtheria in Paris is almost certainly due to the general employment of the antitoxin treatment, another influence is also at work, viz., the ebb of the tide of epidemic prevalence. The antitoxin treatment was described by M. Roux at the Buda-Pesth International Congress of Hygenie and Demography, in September, 1894, and had not up to that time been used on a very extensive scale. A glance at the Paris curve, however, will show that during the four preceding years the death-rate from diphtheria had very materially declined. The question might be further elucidated by a comparison between the number of cases of diphtheria and the number of deaths from this disease, if this were available. The above remarks as to the disturbing influence of the antitoxin treatment apply also to the statistics of other cities. The three provincial cities, Bordeaux, Lyons, and Marseilles, all show a similar decline in mortality from 1891 onwards. There are, however, some minor differences. Bordeaux had the apex of its curve in 1888, Lyons in 1890, and Marseilles in 1890–91, the two latter much behind the Paris curve.

Place.	Years of observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria *plus* Croup. Mean death-rate per 100,000 for the entire period.
		Highest.	Lowest.	
Paris . . .	1865–96	121 in 1877	17·5 in 1895–6	63*
Bordeaux . .	1886–96	78 „ 1888	4 „ 1896	37
Lyons . . .	1886–96	95 „ 1890	12 „ 1896	45
Marseilles . .	1886–96	198 „ 1891	28 „ 1895	113

* Obtained by the less accurate but only available method of adding together the annual death-rates and dividing by the number of years.

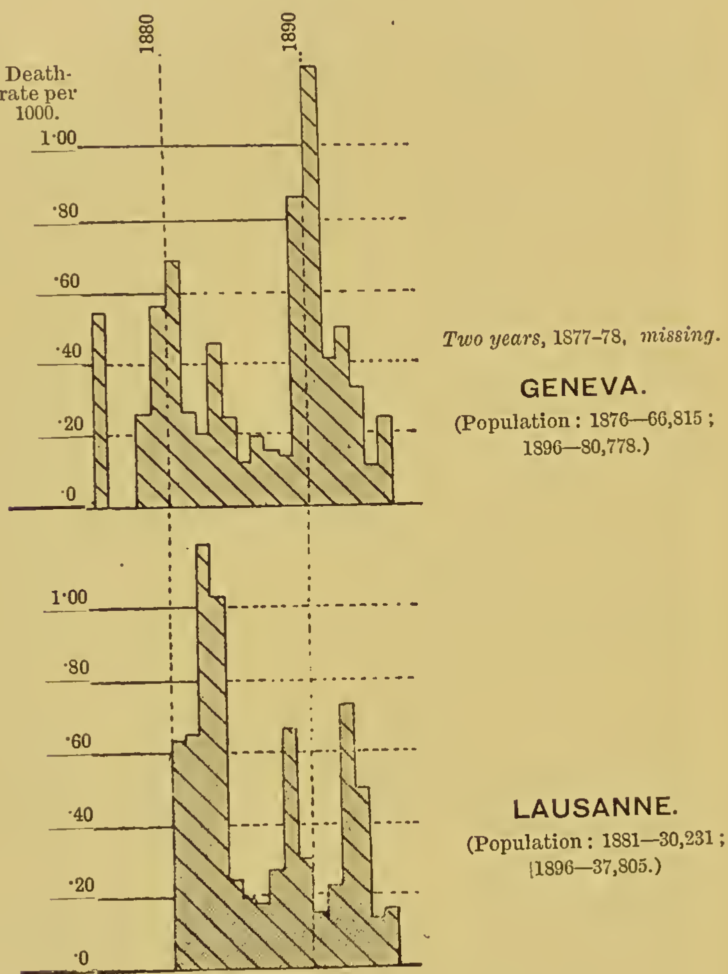
Switzerland.

The returns from *Geneva* and *Lausanne* show a very considerable amount of diphtheria. The first epidemic shown on the curves reached its maximum in 1881 in Geneva, in 1883 in Lausanne. This may be compared with the 1881 maximum in Turin. The more recent epidemics in the two Swiss towns were also not simultaneous in time.

Spain and Portugal.

In *Barcelona,* in 1881, 122 deaths from diphtheria *plus* croup were recorded, giving a death-rate of 43 per 100,000.

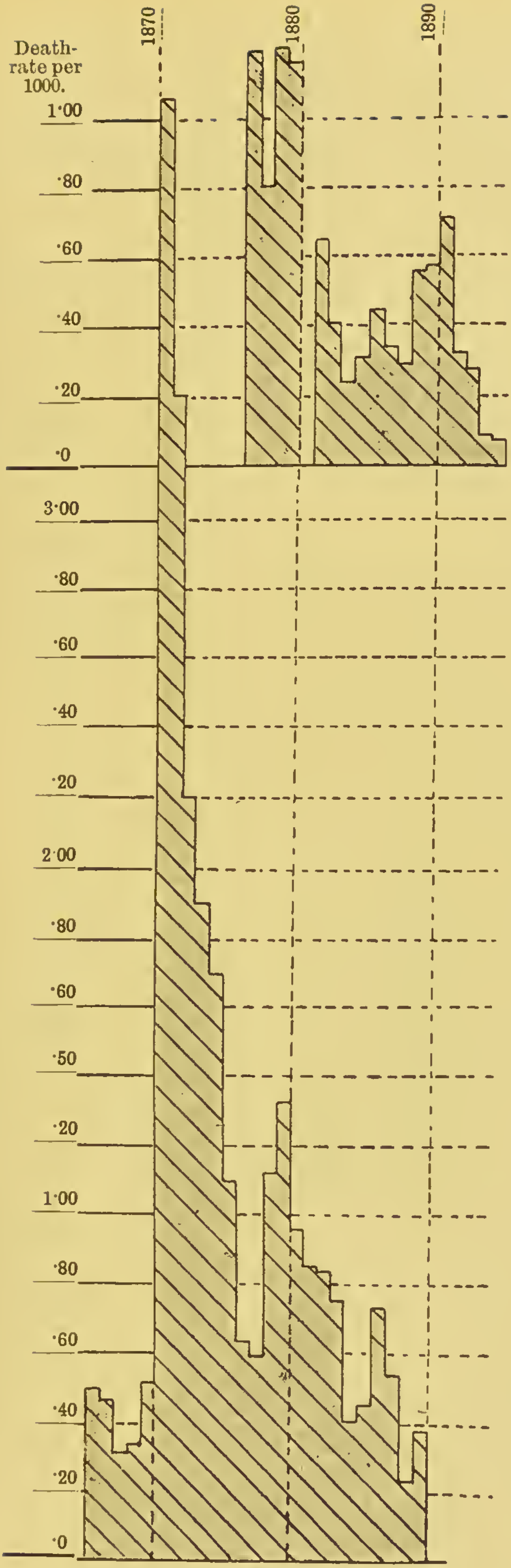
In *Lisbon,* in 1882 and 1883, 141 and 104 deaths from diphtheria were recorded according to the annual summary of the Registrar-General, giving a death-rate of 70 and 51 per 100,000 respectively. From the official weekly records of mortality in Lisbon, for the five years 1892–96, received by the author, it appears that diphtheria *plus* croup caused 44 deaths in 1892, 50 in 1893, 72 in 1894, 89 in 1895, and 51 in 1896. The census population in 1878 was 242,297; in 1890, 301,206. If we assume a uniform population of 305,000 for the above years, the death-rate became 14, 16, 14, 29, and 17 per 100,000 respectively. It is evident, therefore, that in these years Lisbon was enjoying an inter-epidemic period.



Italy.

The Italian returns all combine diphtheria and croup together.

The return for *Florence* embraces a period for which the other Italian returns are deficient. It is remarkable for the extraordinarily fatal epidemic of 1871–75, which was followed by a smaller epidemic in 1879–80. In 1871



The record for 1881 *is missing.*

ROME.

(Population : 1877—278,099 ;
1895—465,563.)

FLORENCE.

Fig. 26.

the death-rate from diphtheria *plus* croup exceeded 4 per 1,000 inhabitants.

Turin had an epidemic culminating in 1881. The epidemic at *Rome*, so far as can be judged from the imperfect returns, culminated in 1877–79. At Venice an epidemic culminated in 1875–76, thus following close on the more virulent epidemic at Florence. Both Rome and Venice show a later maximum in 1891, and Milan a maximum in 1893, which Turin has hitherto escaped.

Place.	Years of observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria *plus* Croup. Mean death-rate per 100,000 for the entire period.
		Highest.	Lowest.	
Turin . . .	1879–95	111 in 1881	22 in 1895	45
Milan . . .	1973–96	267 „ 1874	47 „ 1887	99
Venice . . .	1870–96	97 „ 1891	7 „ 1886	33
Florence . .	1866–90	422 „ 1871	23 „ 1884	83
Rome . . .	1877–95	122 „ 1879	8 „ 1895	21

Holland and Belgium.

The curves for the *Hague*, *Rotterdam*, and *Amsterdam*, from 1879 onwards, show that all these towns had an epidemic of diphtheria, which culminated in Amsterdam and Rotterdam in 1883–84, and in the Hague in 1885. From this point onwards there are sharp distinctions. At the Hague and Rotterdam, there was a marked remission of the disease, while in Amsterdam, although there was also a remission, the total amount of the disease remaining endemic was much greater than that in the foregoing towns. Furthermore, the next epidemic reached its maximum in 1890 in Amsterdam, and at the Hague and in Rotterdam it only culminated in 1892. The curve for Rotterdam shows two earlier epidemics, 1867 and 1873, with which no comparison for the Hague and Rotterdam is practicable.

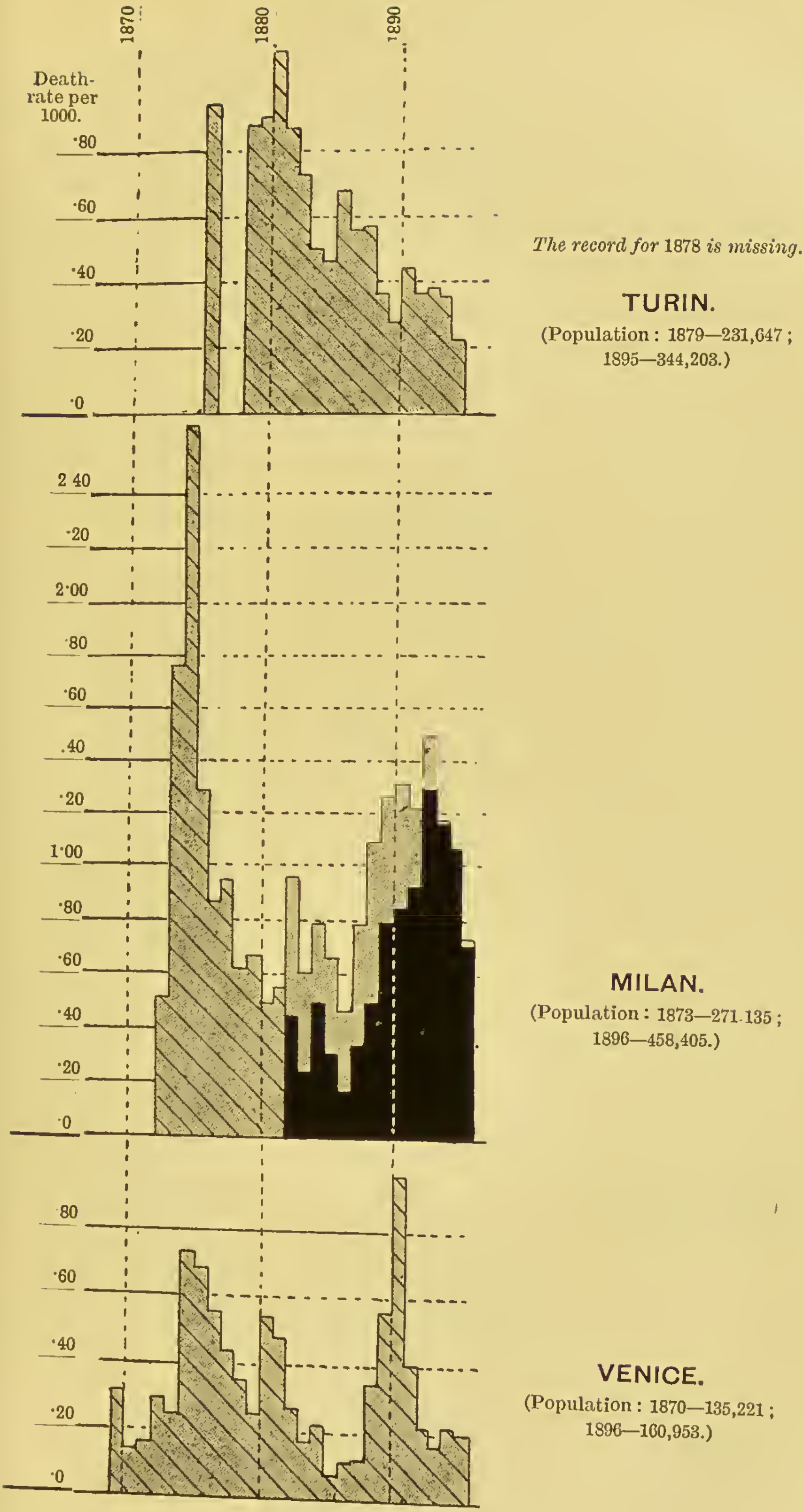

1870
1880
1890
Death-rate per 1000.
·80
·60
·40
·20
·0
The record for 1878 is missing.
TURIN.
(Population : 1879—231,647 ; 1895—344,203.)
2 40
·20
2·00
·80
·60
.40
·20
1·00
·80
·60
·40
·20
·0
MILAN.
(Population : 1873—271.135 ; 1896—458,405.)
80
·60
·40
·20
·0
VENICE.
(Population : 1870—135,221 ; 1896—160,953.)

Fig. 27.

From *Antwerp* returns have been received which give the deaths from diphtheria and croup together from 1860–66, and again, 1887–93, while for other years they are stated separately. The curve based on these returns presents a great epidemic, culminating in 1864–65; an excessive prevalence of the disease in 1870–80; an epidemic, culminating in 1883, and a recent epidemic in 1894. All through the years, although there is evidently some transference between diphtheria and croup, it is plain that diphtheria was endemically present (as also in Amsterdam) to an excessive extent.

The returns for the city of *Brussels* do not distinguish between diphtheria and croup. Those for the city and its suburbs together, dating from 1876, give the two separately. The latter returns deal with a population, in 1896, of 518,387, as compared with 190,313 in the city. There was a great epidemic of the disease, culminating in 1862–65, and it remained very excessively prevalent until the end of the decennium 1861–70, only reaching its minimum point between 1876 and 1881. Then followed an epidemic, the greatest mortality from which occurred in 1885, a year or two later than the corresponding maxima in Antwerp and Amsterdam. The curve for L'Agglomeration Bruxelloise follows the course of the city curve, so far as the 1885 maximum is concerned. It would appear that the earlier epidemic in the city did not subside in the suburbs for several years after the minimum was reached in the city.

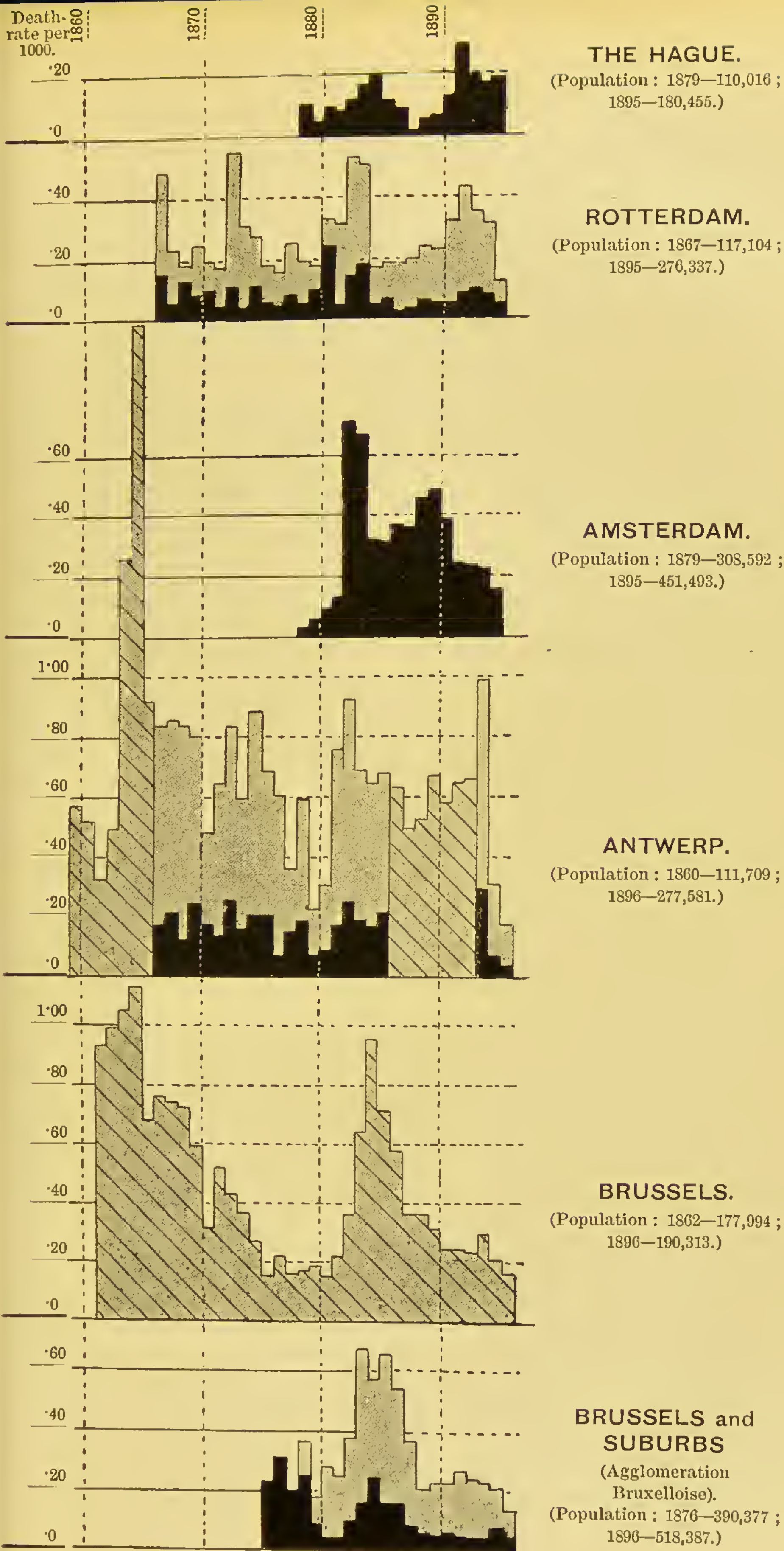

Death-rate per 1000.
1860
1870
1880
1890
THE HAGUE.
(Population : 1879—110,016 ; 1895—180,455.)
ROTTERDAM.
(Population : 1867—117,104 ; 1895—276,337.)
AMSTERDAM.
(Population : 1879—308,592 ; 1895—451,493.)
ANTWERP.
(Population : 1860—111,709 ; 1896—277,581.)
BRUSSELS.
(Population : 1862—177,994 ; 1896—190,313.)
BRUSSELS and SUBURBS
(Agglomeration Bruxelloise).
(Population : 1876—390,377 ; 1896—518,387.)

Fig. 28.

Place.	Years of observation.	Death-rate per 100,000.					
		Diphtheria *plus* Croup.		Diphtheria alone.		Mean death-rate for the entire period.	
		Max.	Min.	Max.	Min.	Diphtheria *plus* Croup.	Diphtheria alone.
The Hague .	1879–95	—	—	30 in 1892	1 in 1888	—	12
Rotterdam .	1879–95	—	—	19 in 1884	2 in 1887	—	7
Amsterdam .	1879–95	—	—	72 in 1883	3 in 1879	—	31
Brussels . .	1862–96	113 in 1865	15in1881 & 1876	—	—	47	—
Antwerp . .	1860–96	217 in 1865	17 in 1896	—	—	67	—

CHAPTER VII.

GERMANY, AUSTRO-HUNGARY, AND RUSSIA.

THE great seaport of *Hamburg* has an enormous amount of diphtheria endemically present. *Berlin* has even more; and most other German cities show an excessive endemicity of this disease. This can be seen by a glance at Figs. 29 to 34.

The returns for Hamburg are exceptionally complete through the kindness of Dr. Reincke, the head of the Statistical Bureau of the city. He has obtained the early returns specially for me, they not having been published before. Diphtheria and croup are classed together. Even when allowance is made for the probable incompleteness of the earlier returns and for changes of nomenclature, it appears clear that there was no very great epidemic of diphtheria between 1838 and 1860, though smaller epidemics culminated in 1838, in 1843-44, and in 1852. Then appear epidemic peaks in 1862 and 1869.

The first great epidemic visible in the *Hamburg* curve culminated in 1873–74. It was two years later (1875–76) in Berlin and Breslau. In *Leipzig* the time incidence was the same as in Hamburg; while in Frankfort-on-the-Main the epidemic occupied the years 1876–79. The comparative lightness of this outbreak in *Breslau* and Frankfort-on-the-Main as compared with the outbreaks a few years earlier in Hamburg and Leipzig, and with the outbreak about the same time in Berlin, may be noted.

The next epidemic occurred earlier in Berlin than in Hamburg, the remission between the Berlin epidemic culminating in 1875–76 and that culminating in 1883–84 being slight. Leipzig had an epidemic culminating also

HAMBURG.

(Population: 1821—129,985; 1896—1,695,726.)

Returns are missing for 1823-37, 1841-42, 1858, 1863-35, and for 1871.

Fig. 29.

in 1883–84; at Dresden it was still earlier (1881–83). At Hamburg it only reached its maximum in 1885–87, at

Breslau, 1887–88. In Frankfort it was still later and more protracted, only commencing materially to decline about 1893. The whole series of German curves is worthy of careful study in its bearing on the hypothesis of gradual progression of the disease from town to town.

BERLIN.

(Population: 1868—716,088; 1896—1,693,726.)

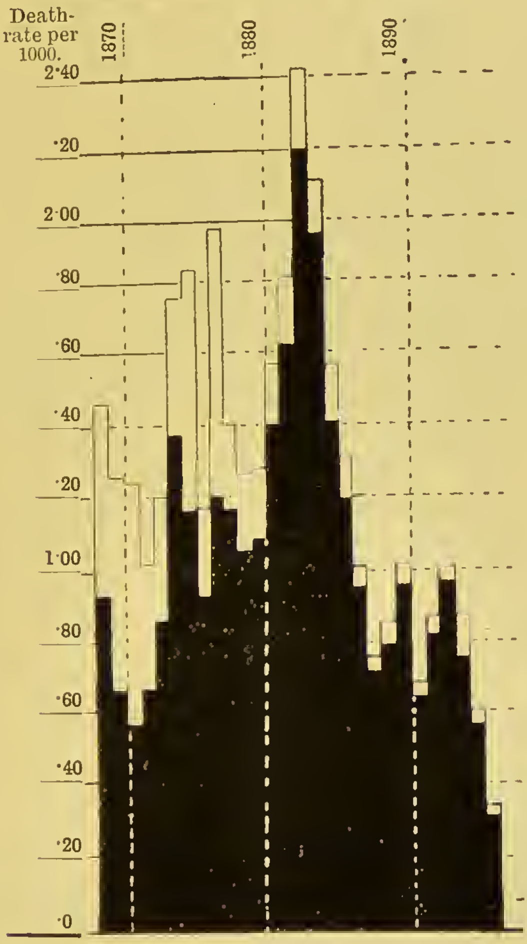


Fig. 30.

(Through an oversight, the part of this diagram representing the death-rate from croup is indicated by white columns enclosed by black lines, instead of by stippled columns, as in all the other diagrams.)

The *Frankfort* records go back to 1851. In the first ten

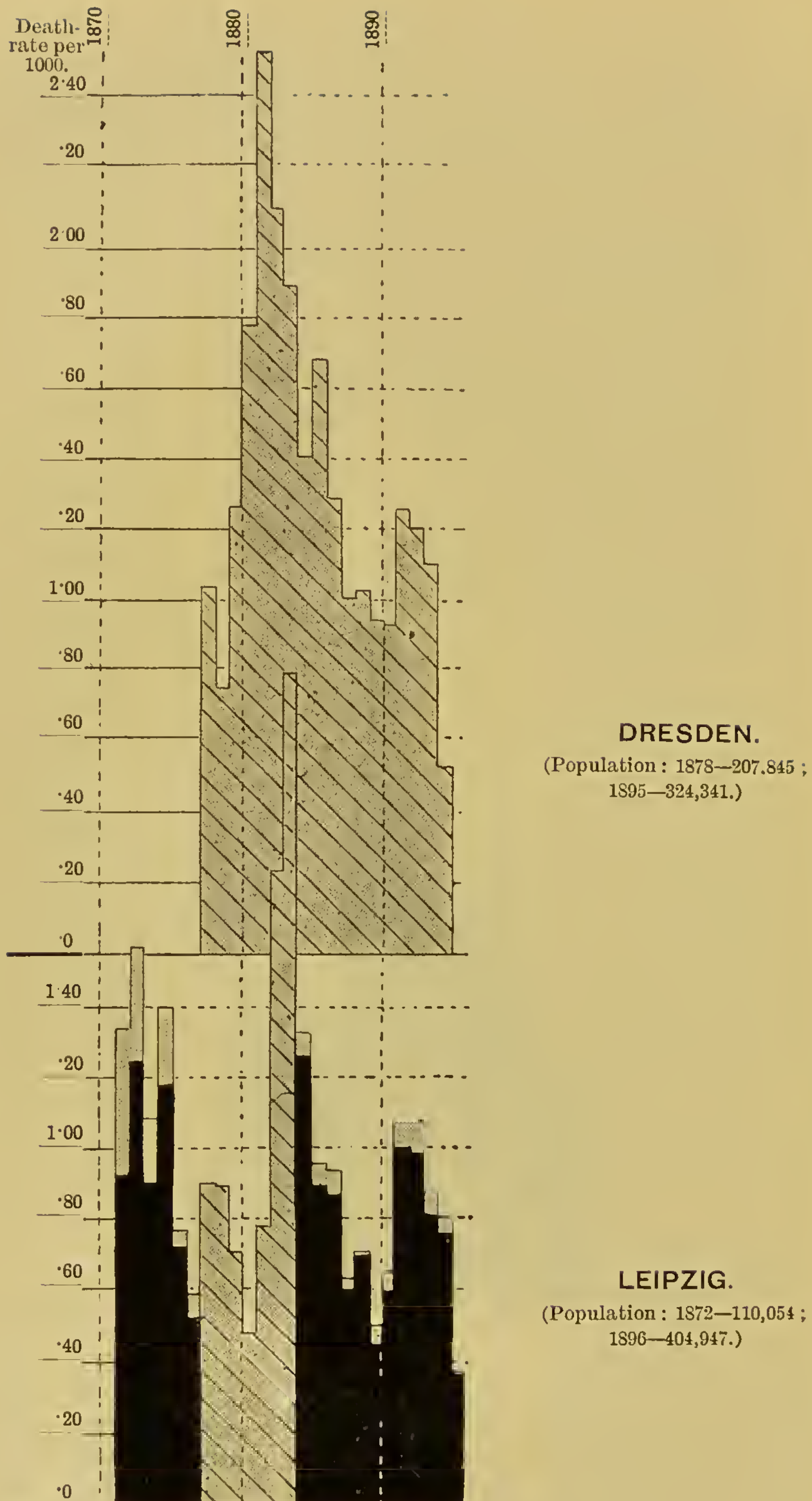

Death-rate per 1000.
1870
1880
1890
2·40
·20
2·00
·80
·60
·40
·20
1·00
·80
·60
·40
·20
·0
1·40
·20
1·00
·80
·60
·40
·20
·0
DRESDEN.
(Population: 1878—207,845; 1895—324,341.)
LEIPZIG.
(Population: 1872—110,054; 1896—404,947.)

Fig. 31.

BRESLAU.

(Population: 1866—168,201; 1896—378,089.)

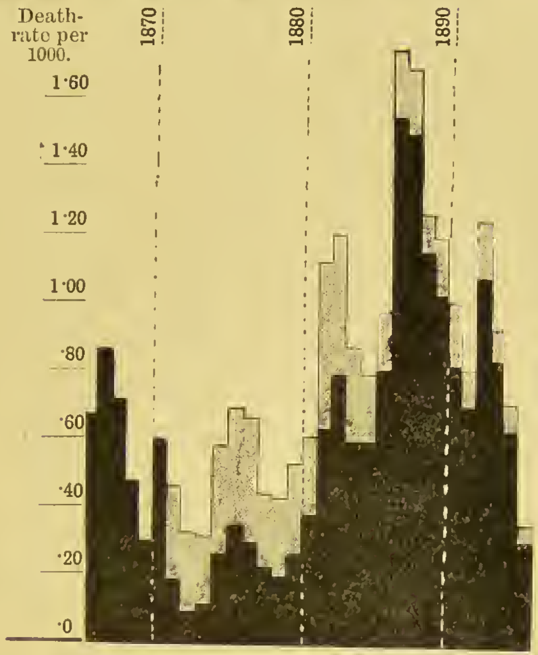


Fig. 32.

FRANKFORT-AM-MAIN.

(Population: 1851—36,396; 1895—226,000.)

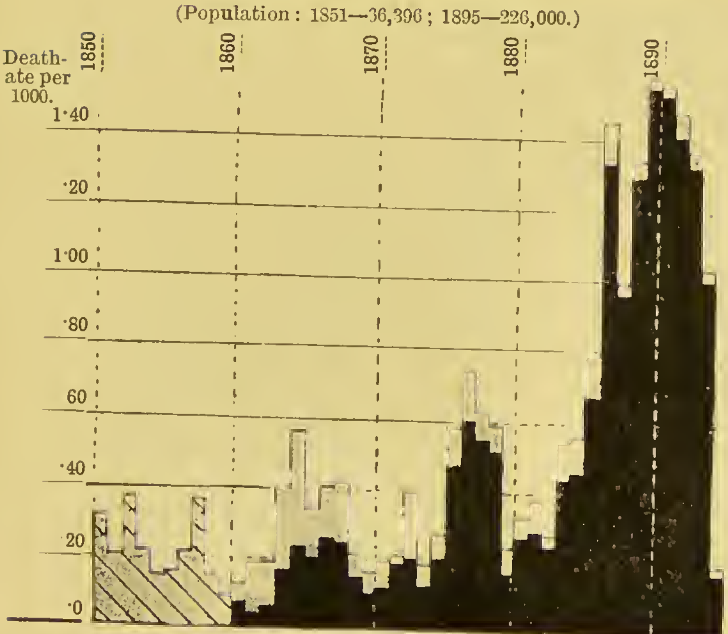


Fig. 33.

years they combine diphtheria and croup; after this, deaths under the two names are separately classified. The curve shows evidence of excessive prevalence of diphtheria in 1851–60, and indicates that the next epidemic (described in previous instances as the "early epidemic") did not culminate at Frankfort until 1865.

The *Munich* curve shows a large endemic prevalence of diphtheria *plus* croup, with epidemics culminating in 1868–69, in 1880–81, and in 1889–90 respectively. These maxima present interesting variations from the corresponding maxima in the other German curves, and in the Austrian curves to be next considered.

MUNICH.

Return for 1875 *missing.*

(Population: 1868—151,562; 1895—396,000.)

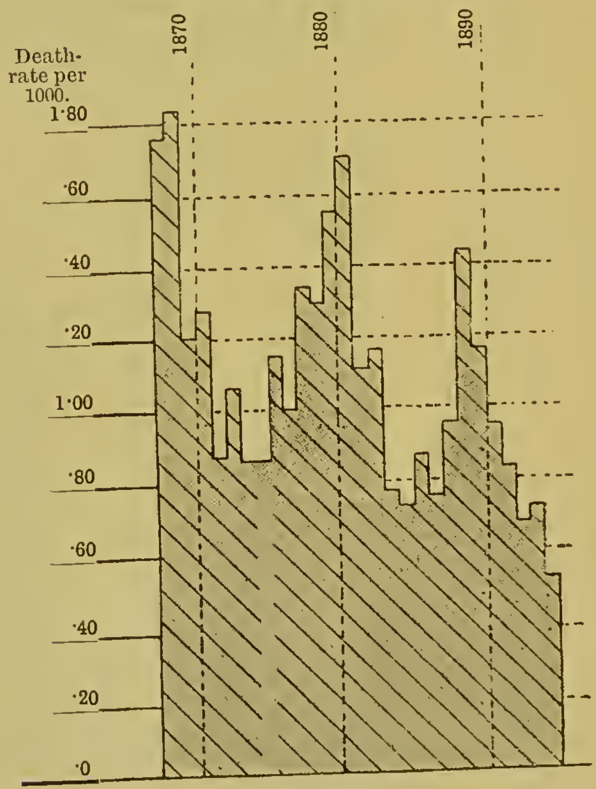


Fig. 34.

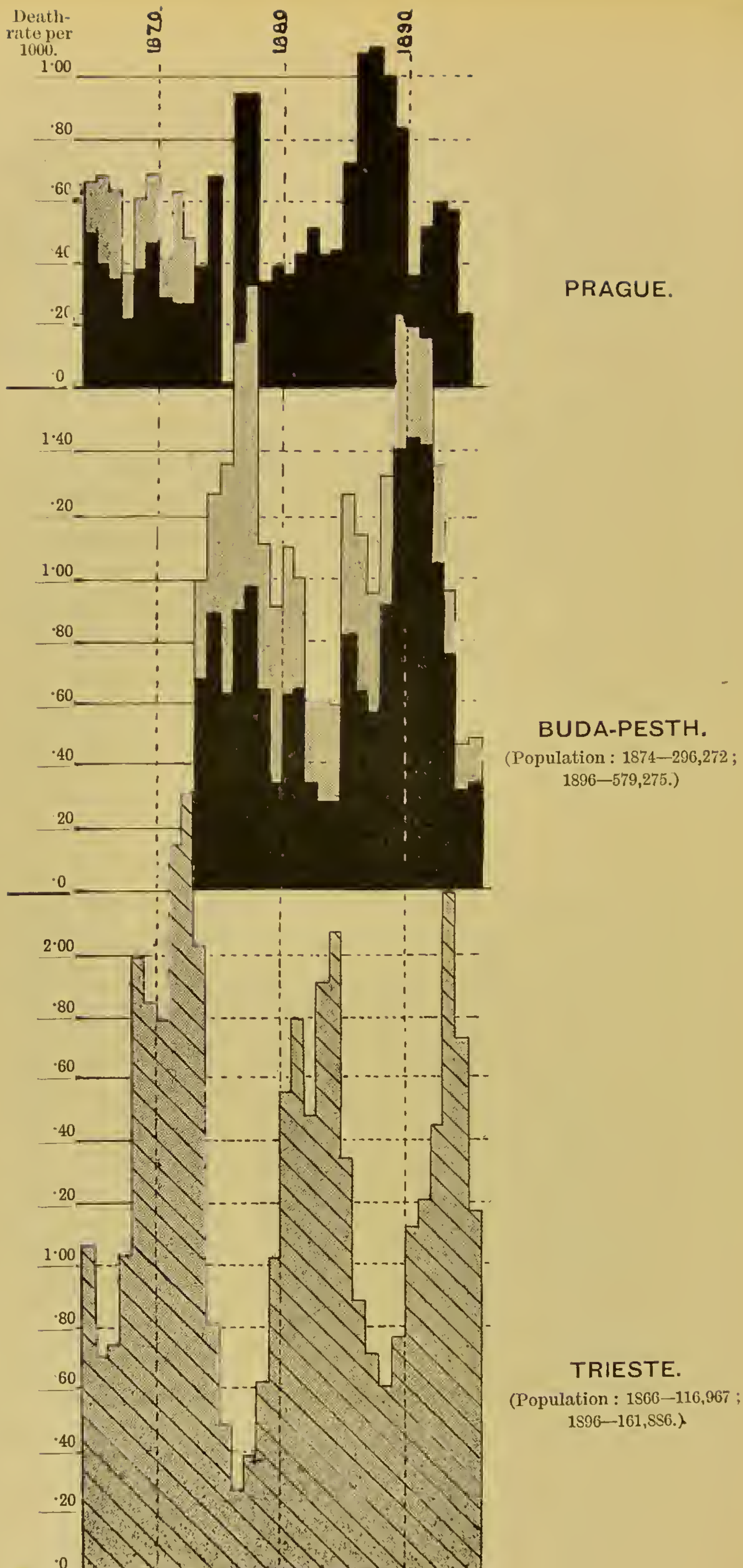
Place.	Years of observation.	Diphtheria *plus* Croup. Death-rate per 100,000.		Diphtheria alone. Death-rate per 100,000.		Mean Death-rate per 100,000 for the entire period.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Hamburg	1872–95*	123 in 1887	17 in 1896	—	—	49	—
Berlin	1869–96	242 in 1883	34 in 1896	220 in 1883	31 in 1896	119	101
Breslau	1866–96	162 in 1887	28 in 1870	—	—	78	—
Dresden	1878–95	253 in 1882	52 in 1895	—	—	129	—
Leipzig	1872–96	234 in 1884	37 in 1896	—	—	90	—
Frankfort-on-the-Main	1851–95	160 in 1890	9 in 1860	157 in 1890	7 in 1862	64	53
Munich	1868–74 1876–95	184 in 1869	53 in 1895	—	—	99	—

* The figures for Hamburg relate to a shorter series of years than the curve in Fig. 29.

Austro-Hungary.

We may commence with *Trieste*, which lies at the upper end of the Adriatic Sea on its eastern side, Venice being on the western side. The diagram shows three great epidemics, and a large endemic prevalence of the disease. The first epidemic ranges from 1869 to 1874. The first epidemic ranges from 1869 to 1874, culminating in 1873; the second from 1881 to 1886, culminating in 1885; while the third, which began in 1891, culminated in 1894.

The returns for *Buda-Pesth* date back only to 1874. The first epidemic shown on the diagram reached its maximum in 1878. This may be regarded as a sequel to the 1871–75 epidemic in Trieste; or if it be assumed that the infection travelled southwards and to the west, then the Trieste epidemic of 1881–85 would correspond to the Buda-Pesth epidemic of 1871–79. In 1886 another severe



Death-rate per 1000.
1870
1880
1890
1·00
·80
·60
·40
·20
·0
1·40
·20
1·00
·80
·60
·40
20
·0
2·00
·80
·60
·40
·20
1·00
·80
·60
·40
·20
·0
PRAGUE.
BUDA-PESTH.
(Population : 1874—296,272 ; 1896—579,275.)
TRIESTE.
(Population : 1866—116,967 ; 1896—161,886.)

Fig. 35.

epidemic of diphtheria began in Buda-Pesth, which reached its maximum in 1890-92, and then rapidly declined.

Vienna showed a fairly steady endemic prevalence of diphtheria between 1865 and 1870. In 1876–79 it suffered from a severe epidemic, which was repeated in 1891–94. The time incidence of these epidemics corresponds fairly well with that of Buda Pesth, which is on the banks of the Danube, at a lower point than Vienna. The recent epidemic was, however, later in Vienna than Buda-Pesth, reaching its acme in 1892–94, instead of in 1890–91.

The returns for *Prague* show epidemics reaching their maxima in 1877–78 and in 1887–89 (Fig. 35).

VIENNA.

(Population: 1865—561,647; 1895—1,488,463.)

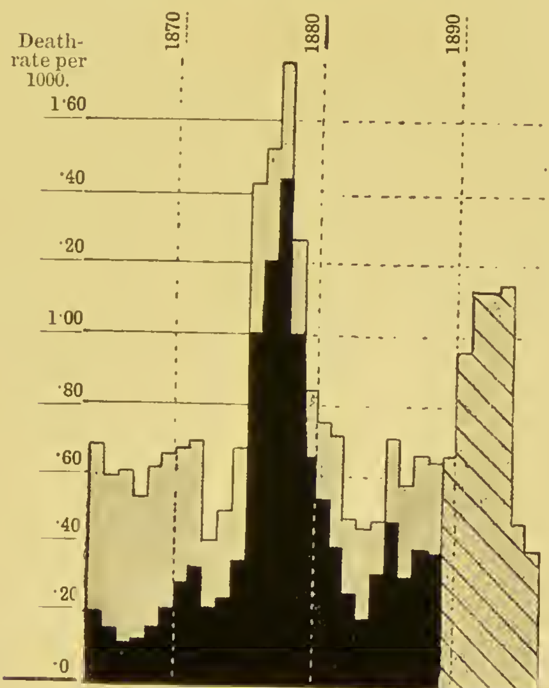


Fig. 36.

Place.	Years of observation.	Death-rates per 100,000.					
		Diphtheria *plus* Croup.		Diphtheria alone.		Mean Death-rate.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Trieste . .	1865–96	251 in 1873	27 in 1877	—	—	130	—
Buda Pesth .	1874–96	194 in 1878	46 in 1895	140 in 1891	29 in 1884–5	108	68
Vienna . .	1865–96	177 in 1878	42 in 1873	(144 in 1878)*	(19 in 1884)	77	—
Prague . .	1865–95	—	—	110 in 1888	1 in 1876	—	—

* The "Diphtheria alone" returns for Vienna refer to the years 1865–89.

Russia.

St. Petersburg suffered from a severe epidemic of diphtheria in 1881–83, which in 1882 caused a death-rate of 1·52 per 1000 of population. A later epidemic culminated in 1894.

At *Moscow* the disease appears to have been continuously present in greater amount than at St. Petersburg, but there were epidemics about the same time as at St. Petersburg. The 1882 maximum corresponds to the 1883 maximum in Berlin.

(There is some doubt as to whether the height of the latter part of the curve for Moscow is not exaggerated, in consequence of doubt as to its true population. The oscillations alone must, therefore, be regarded, and not the general upward direction of the curve.)

In *Warsaw,* judging by such records as are available, there is a large amount of diphtheria. The death-rate from diphtheria *plus* croup in 1885 was 101, and in 1887 was 72 per 100,000 of population. These figures are derived from the annual summaries of the English Registrar-

General. The following figures are derived from a paper in the *Proc. Buda-Pesth Congress*, tome iv., p. 452.

Year.	Death-rate from Diphtheria *plus* Croup per 100,000.
1877	53
1878	100
1880	118
1882	176
1884	161
1886	98
1888	75
1890	63
1892	67

Place.	Years of observation.	Death-rate per 100,000.					
		Diphtheria *plus* Croup.		Diphtheria alone.		Means for the entire period.	
		Max.	Min.	Max.	Min.	Diphtheria *plus* Croup.	Diphtheria alone.
St. Petersburg	1879–90 1892–95	—	—	154 in 1882	27 in 1893	—	65
Moscow	1878–96	111 in 1894	35 in 1878	105 in 1893	27 in 1880	72	64

Roumania.

At Bucharest, in the year 1880, 135 deaths from diphtheria were recorded, equal to a death-rate of 67 per 100,000 of the population.

No other returns have been secured.

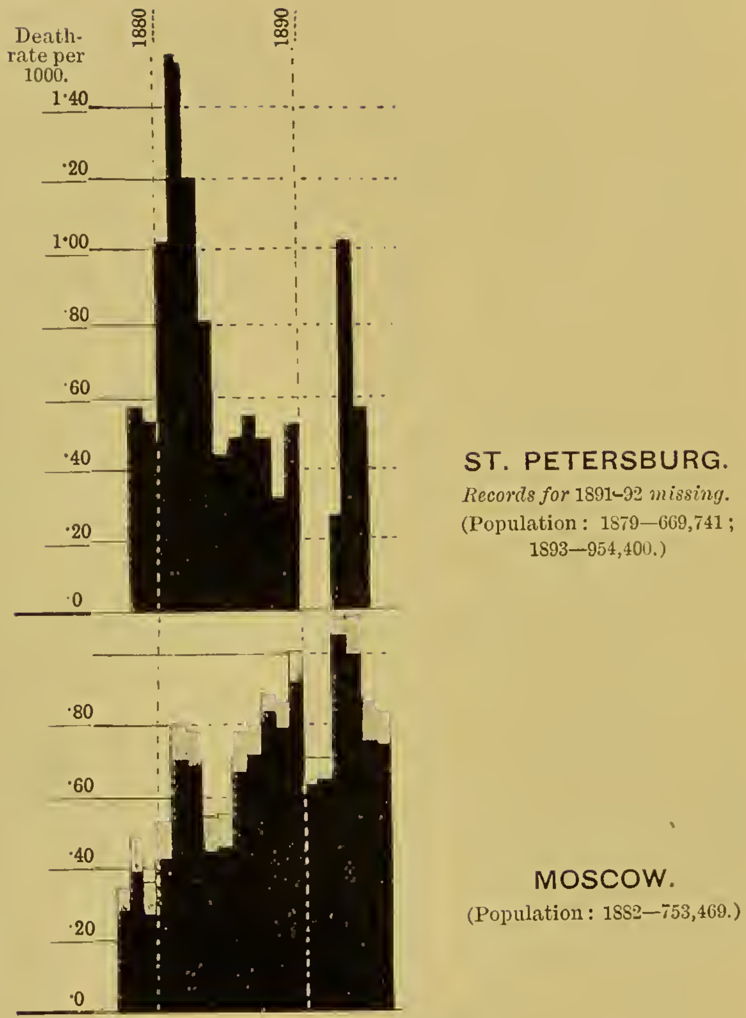

Death-
rate per
1000.
1·40
·20
1·00
·80
·60
·40
·20
·0
1880
1890
ST. PETERSBURG.
Records for 1891–92 *missing.*
(Population: 1879—669,741; 1893—954,400.)
·80
·60
·40
·20
·0
MOSCOW.
(Population: 1882—753,469.)

Fig. 37.

CHAPTER VIII.

SCANDINAVIA.

The Scandinavian death returns for diphtheria are of great importance for several reasons. They embrace a long period of years. They can be supplemented and checked by a corresponding record of cases of *sickness*, based on a national system of notification of certain forms of sickness in the whole of Norway and Denmark. They have a further interest because they relate to sparsely populated countries, in which the influence of epidemics can be easily seen; and in which the inter-epidemic periods might be expected on *a priori* grounds to be well marked. That this is so is shown very clearly by the curves for Christiania, Gottenburg, Stockholm, and Copenhagen.

The curve for *Christiania* shows a large epidemic, reaching its maximum in 1862, but well on its way in 1860, when the record commences. For some years afterwards the amount of diphtheria was excessive, but between 1870 and 1880 there was little of it. In 1884 an epidemic of enormous magnitude commenced, lasting with great force until 1891. The highest death-rates from diphtheria *plus* croup were in 1885 and 1887, in which they were 3·28 and 3·29 per 1000 of the population respectively.

The curve for the whole of *Norway* presents identical epidemics, with minor differences (see Fig. 47, p. 104). The earlier portions of the two curves are almost identical in shape; but the more recent epidemic is somewhat more protracted than in Christiania, and takes a longer time in attaining its maximum than in the capital town, not reaching it until 1890. This is what might have been foretold in view of the scattered distribution of the Norwegian population.

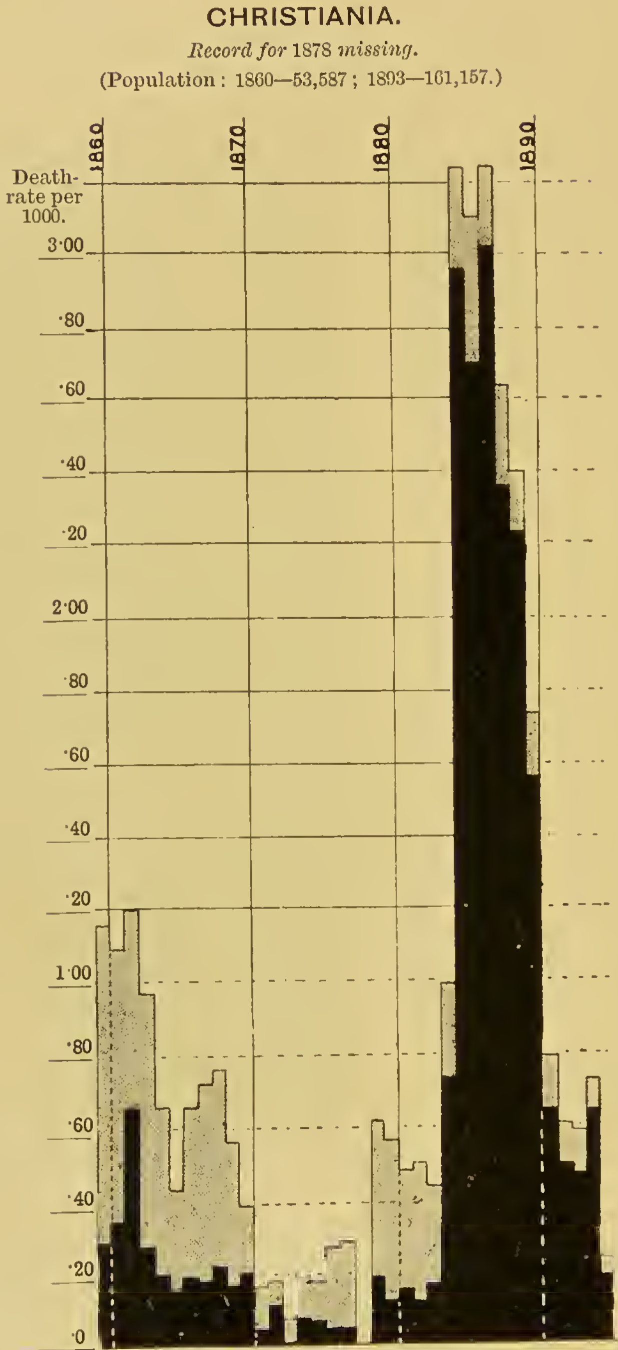


Fig. 38.

Gottenburg had the early epidemic like Christiania, but it began to decline earlier than in the latter. In 1871–73 it had an epidemic, which is quite unrepresented in Christiania; and the next epidemic is earlier in Gottenburg than in Christiania, reaching its acme in 1884 instead

GOTTENBURG.

(Population: 1863—41,200; 1895—117,512.)

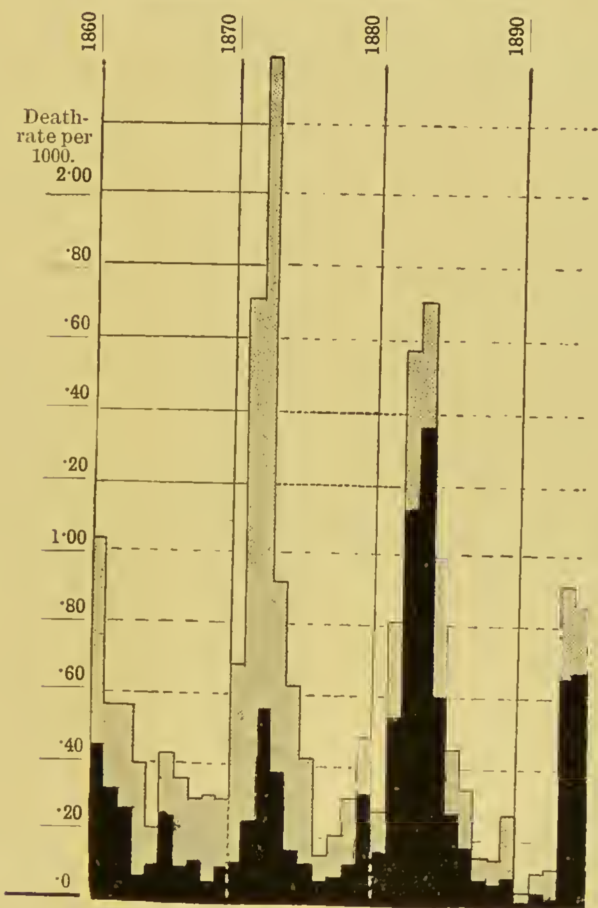


Fig. 39.

of 1885–87. It would appear, however, that Christiania had accumulated in the longer interval a much more "explosive" population, if we may judge from the enormous epidemic among its population which followed close on the heels of the 1882–85 epidemic in Gottenburg.

Gottenburg showed the commencement of another epidemic in 1894–95. Attention may be directed to the regular intermission of its epidemics, an interval of ten or twelve years intervening between the maxima of its respective epidemics. It seems impossible to resist the surmise that Gottenburg is nearer to and more easily influenced by some centre of infection than the more distant Christiania. A comparison with the next curves will confirm this surmise, though it must be confessed that the view taken as to the direction in which infection travelled will depend on the point from which one starts. It is probable that no uniformity in this respect exists, and that there is exchange in infection as in the commerce with which it is closely associated.

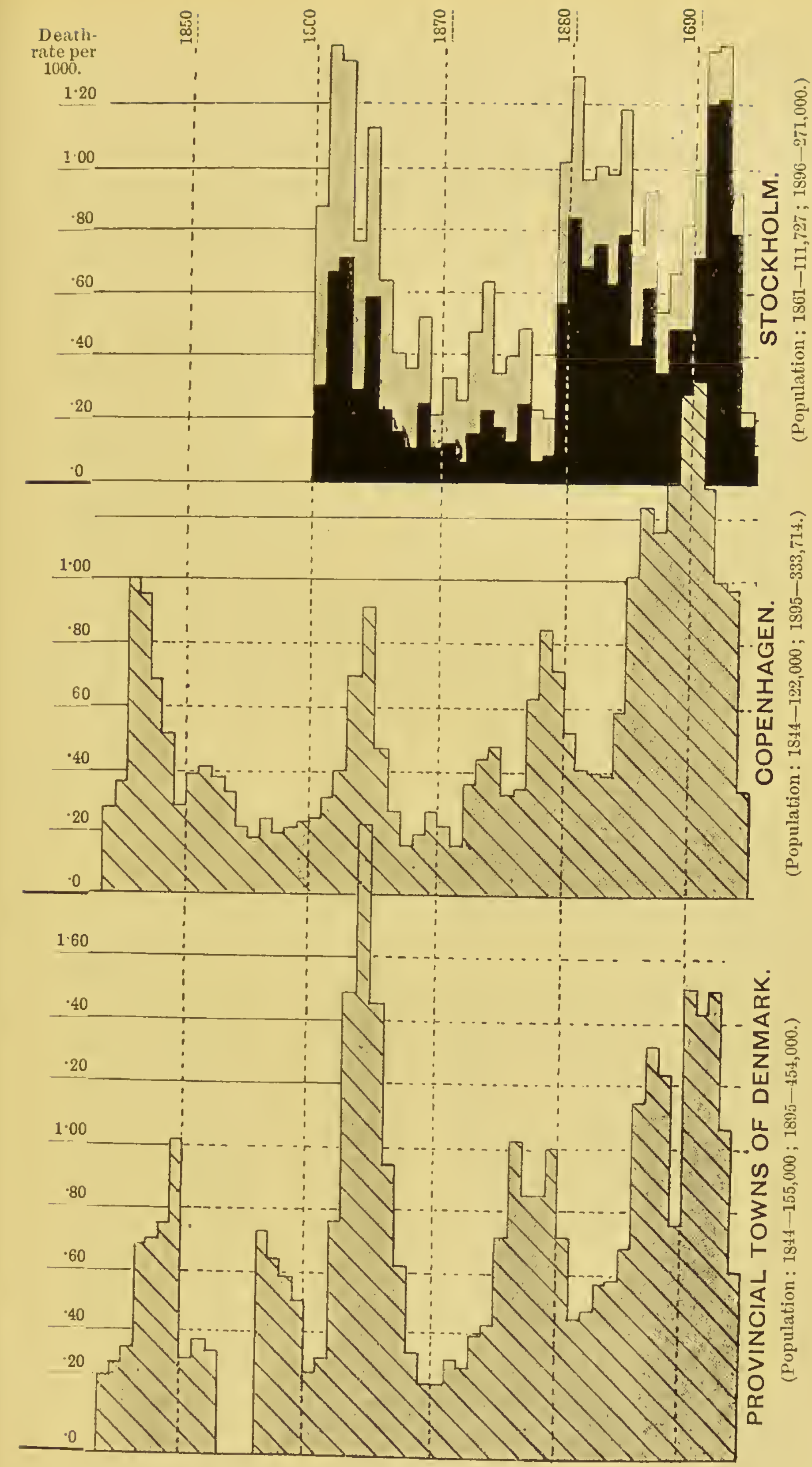
Stockholm, like Copenhagen and other Danish towns, shows much more diphtheria endemically present than either Gottenburg or Christiania. They are both more closely connected geographically and commercially with the main portion of the European continent than is Gottenburg, and still less Christiania. Hence probably they keep up the supply of infection more frequently from Germany and other centres of diphtheria.

Stockholm shows an epidemic 1861–64. In 1880 an epidemic began lasting several years, which after only a small remission was followed by a greater epidemic in 1892–93.

The returns for *Copenhagen* and *Provincial Towns* of Denmark go back to 1845.* They both show a very considerable epidemic in 1846–49, of which we have but scant statistical records for the European continent.†

* These figures are derived from Dr. Carlsen's paper in *Janus*, September, 1896.

† Compare Fig. 29, Hamburg, and Fig. 33, Frankfort-on-the-Main, for records at or near the same period.



Death-rate per 1000.
1850
1860
1870
1880
1890
STOCKHOLM.
(Population: 1861—111,727; 1896—271,000.)
COPENHAGEN.
(Population: 1844—122,000; 1895—333,714.)
PROVINCIAL TOWNS OF DENMARK.
(Population: 1844—155,000; 1895—454,000.)

Fig. 40.

This epidemic culminated in Copenhagen in 1846, in the provincial towns not until 1850.* The latter, it must be remembered, represents the combined experience of a large number of towns, and indicates, therefore, the gradual progression of the infection.

The next epidemic, a large one, reached its maximum in 1865, not so early as at Christiania or Stockholm. The next epidemic was most prevalent in 1877–80. There was a very considerable remission in 1881–86, and then came an epidemic lasting from 1886 to 1894, and culminating in 1891 in Copenhagen, not until 1891–94 in the provincial towns.

Place.	Years of observation.	Death-rate per 100,000.					
		Diphtheria *plus* Croup.		Diphtheria alone.		Mean Death-rate for the entire period.	
		Highest.	Lowest.	Highest.	Lowest.	Diphtheria *plus* Croup.	Diphtheria alone.
Christiania .	1860–93	329 in 1887	17 in 1871	303 in 1887	1 in 1873	109	80
Gottenburg .	1861–95	250 in 1873	5 in 1891	137 in 1884	3 in 1891	58	23
Stockholm .	1861–96	139 in 1893 & 1862	12 in 1896	121 in 1893	6 in 1878	72	45
Copenhagen	1844–95	164 in 1891	15 in 1868 & 1872	—	—	64	—
Provincial Towns of Denmark	1844–95	203 in 1865	15 in 1872	—	—	84	64
Whole of Norway	1860–91 Diph. 1867–91 Diph. and Croup	123 in 1890	11 in 1870	110 in 1890*	2 in 1866*	49*	50

* These figures relate to the period 1867–91.

The Faroë Islands form a detached part of Denmark, between the Shetland Islands and Iceland, having only

* Compare with these records, the great excess of Croup in London in 1847, shewn in Fig. 13, p. 30.

infrequent communication with the continent of Europe. Their statistics therefore have a special interest, and I am glad to be able to reproduce them from a valuable article in *Janus*, by Dr. J. Carlsen (p. 177, September, 1896).

Year.	Reported Cases.		Deaths.	
	Diphtheria.	Croup.	Diphtheria.	Croup.
1876	48	5	1	—
1877	106	6	?	?
1878	161	32	?	?
1879	118	24	6	17[1]
1880	124	27	7	11
1881	69	5	1	2
1882	94	8	11	3
1883	34	2	4	1
1884	31	1	2	3
1885	27	1	4	2
1886	14	5	4	3
1887	7	—	1	1
1888	6	—	1	1
1889	—	—	—	—
1890	—	—	—	—
1891	6	—	—	—
1892	25	9	5	5
1893	10	8	1	8
1894	35	9	1	7

The maximum prevalence in 1878–80 corresponds closely with that in Denmark. The next minimum was several years later in the Islands than in Denmark, and the Danish epidemic from 1886 onwards did not seriously affect the Faroë Islands until 1892.

CHAPTER IX.

AFRICA AND ASIA.

OUTSIDE Europe and America, with a few exceptions in Australia, statistical records of the incidence of diphtheria are very scanty. I have only succeeded in obtaining a few scattered records from North and South Africa, from India, and from Australasia.

Mortality from Diphtheria plus Croup.

Year.	Alexandria.		Cairo.	
	Recorded Deaths.	Approximate Death-rate per 100,000 Inhabitants.	Recorded Deaths.	Approximate Death-rate per 100,000 Inhabitants.
1879	43	20	—	—
1880	43	20	—	—
1881	33	16	—	—
1882	28	13	456	122
1883	154	73	730	195
1884	105	50	657	175
1885	81	39	829	221
1886	90	37	300	80
1887	59	26	121	32
1888	51	22	85	23
1889	61	26	113	30
1890	119	52	98	26
1891	141	61	90	24
1892	128	55	72	19
1893	107	46	112	30
1894	124	54	86	23
1895	100	43	90	24
1896	142	62	135	36

Judging by the available records, the dry and warm climates of *Cairo* and *Alexandria* are far from being inimical to the prevalence of a large amount of fatal diphtheria. The preceding returns have been supplied by the kindness of Dr. F. W. Sandwith, of Cairo, who organised the health statistics of Egypt. As there has been no census since 1882, it has been necessary to give the actual deaths in each city. A column has been added for each city giving the death-rate based on the population figures as stated in the English Registrar-General's Annual Summaries. (For Alexandria these are given as 212,034 in 1879–84, and 231,396 for 1886–91; and for Cairo, as 374,838 for 1886–87.)

If these returns are to be trusted, Cairo has suffered much more severely from diphtheria than Alexandria. The former city had a most fatal epidemic in 1882–85, culminating in 1885. In Alexandria there was a smaller epidemic during the same years, reaching its maximum two years earlier than the more inland city. In recent years Alexandria has suffered rather more than Cairo.

Cape Colony.

A general system of registration having only been adopted on the 13th July, 1894, statistics are not available for earlier years. According to the Cape of Good Hope Reports on the Public Health, 1894, p. 24, the death-rates from diphtheria *plus* croup in that year were very high; being 80·4 in Cape Town, 83·0 in King William's Town, 92·5 in Worcester, 162·5 in Malmesbury, and 398·4 in Aberdeen, per 100,000 of population.

India.

Calcutta.—I am not in a position to state how far the registration of deaths and the causes of death in this city is effective; but after making a free allowance for incompleteness of registration, the figures published in the Annual Summaries of the English Registrar-General show that there is extremely little diphtheria in Calcutta, and that it has not been epidemic in any year since 1879.

The largest number of deaths registered as due to diphtheria since 1879 was 29 in 1882, which is only equal to a death-rate of 6 per 100,000. The lowest number of deaths was 9 in 1879, which is equal to a death-rate of 1 per 100,000.

The conclusion that diphtheria is a rare disease in India is confirmed by the *Annual Reports of the Sanitary Commissioner with the Government of India.* Thus in the report for 1891, the summary table Z states that during the year only two non-fatal cases of diphtheria were admitted in the Bengal European army (strength 40,953), none in the Madras army (strength 13,268), and none in the Bombay army (strength 12,735); and that in the native army (143,970), and the jail population of India (strength 101,910), there were no cases during the year.

In 1894 there were only two cases (both fatal) in the whole European army in India. In the same year there were only two deaths from diphtheria and eight cases among the children of the European regiments out of an average strength of 5,680. Diphtheria evidently does not thrive in a tropical climate.

Japan.

The Annual Report for the Home Department of the Imperial Japanese Government for 1892 is stated to be for the twenty-fifth year, but I have been unable to secure information as to deaths from diphtheria further back than 1888. The report for 1892 states, however, that the number of cases in Japan in 1892 was greater than in any other year since 1872.

The death-rate in 1892 from diphtheria was 60; in 1893, 7; in 1894, 7; in 1896, 7; and in 1896, 8 per 100,000. The paucity of cases in proportion to these

Year.	Cases.	Deaths.	Population.
1888	2,582	1,450	—
1889	2,669	1,495	—
1890	2,448	1,438	—
1891	3,429	1,974	—
1892	4,359	2,531	41,268,732
1893	5,726	3,205	41,089,940
1894	5,308	2,903	41,388,313
1895	6,100	3,025	41,813,215
1896	8,590	3,279	42,270,620

deaths shows that in all probability their notification is very incomplete.

The figures for the years 1893–96 have been sent me by the Director General of the Sanitary Bureau, Home Department, Japan, who has kindly added the following figures as to the number of patients and deaths from diphtheria in five principal towns in Japan :—

Diphtheria in Japan.

Name of Towns.	1894.				1895.			
	No. of Patients.	No. of Deaths.	Population.	Death-rate per 100,000.	No. of Patients.	No. of Deaths.	Population.	Death-rate per 100,000.
Tokio . .	371	212	1,242,224	17	707	183	1,268,930	14
Kioto . .	111	54	328,411	17	142	43	340,101	13
Osaka . .	129	74	488,937	15	160	55	487,184	11
Yokohama	49	36	160,439	23	80	40	170,252	24
Kobe . .	58	37	158,993	24	62	32	161,130	20

If registration during the above years is fairly complete, the above figures indicate that since 1888 there has been a comparatively small mortality from diphtheria in Japan. They also show that, as in all the countries for which I have been able to secure records, the death-rate from diphtheria is much higher in the towns than in the country at a whole; from which it follows that for the years to which the above records relate, diphtheria is more an urban than a rural disease.

CHAPTER X.

AUSTRALIA AND NEW ZEALAND.

The most complete statistics available are for *South Australia* * (Fig. 43). They show, as do the other Australian curves as far as they extend, that diphtheria is a very fatal endemic disease in Australia, interrupted by epidemic exacerbations at intervals of a few years.

Curves for South Australia (Fig. 43), and for *Victoria* (Fig. 41), show that both these neighbouring colonies suffered severely from the "early" epidemic of diphtheria, in 1858–61. In both of them again, after a very short and imperfect remission, a second epidemic occurred, culminating in 1864. With only a single year's interval (1866) a third epidemic culminated in 1867 in South Australia, a year or two later in Victoria. The record for Victoria is taken from the *Report of the Royal Commission appointed by His Eminence the Governor to inquire into Diphtheria in Victoria*, 1872. The report of this Commission states that attention was first drawn to the existence of diphtheria in Victoria, in 1857. It also mentions that cases of the disease were seen in Melbourne over twenty years ago (*i.e.* presumably before 1852), and that some bad cases of the disease were seen in Castlemaine in 1854–55.

This subject is discussed in a paper entitled "Remarks on the introduction of Diphtheria into Victoria," by Mr. W. Thompson, F.R.C.S. Edin. (*Australian Medical Journal*, July, 1872). In this paper, it was contended that the

* Derived from "A Contribution to the Demography of South Australia," by T. S. Borthwick, M.D. (1891).

disease was imported by passengers who were landing every week at Melbourne from England, where a great epidemic was raging. The first recorded fatal case in Melbourne, he states, occurred in October, 1858, and up to the end of that year only six fatal cases were recorded in the colony. Mr. Thomson quotes official statistics

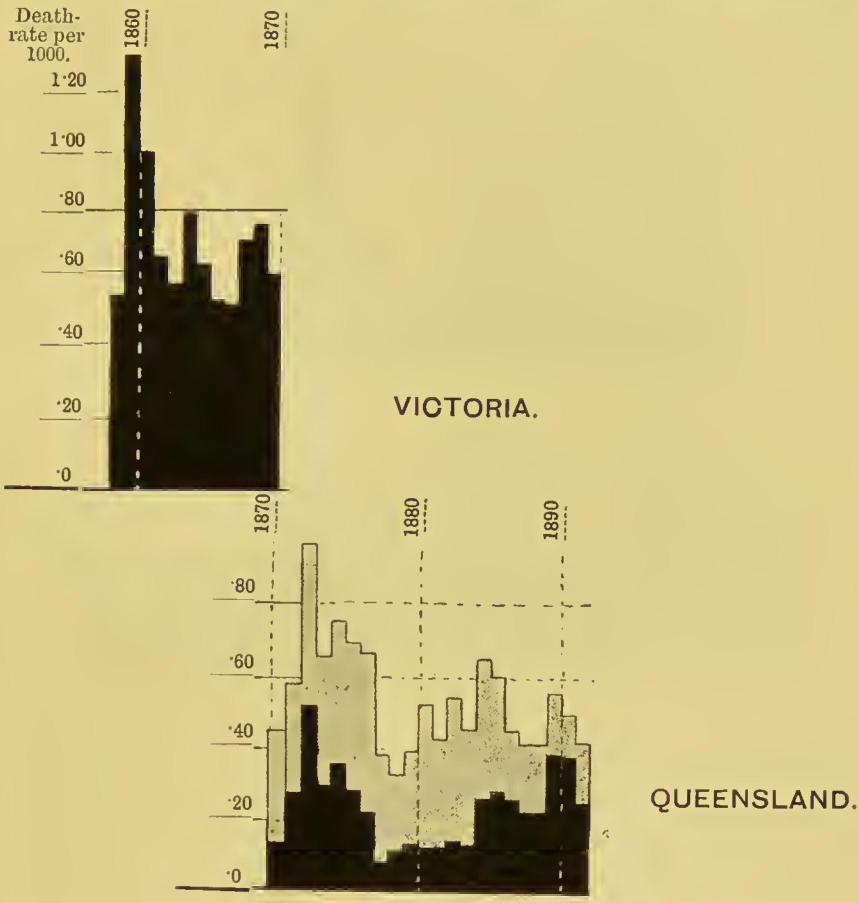


Fig. 41.

for the colony, going back to 1853. These show that, from 1853 onwards, the annual deaths from croup numbered 32 (six months of 1853), 72, 53, 69, 56, 102, 229, 156, 166, the last number being for the year 1861. Diphtheria first appeared in the returns in 1859. A writer in the *Australian Medical Journal*, during 1857, states that he examined the larynx in several fatal cases of croup in Melbourne, without finding any false membrane. Notwithstanding this statement, I am of opinion

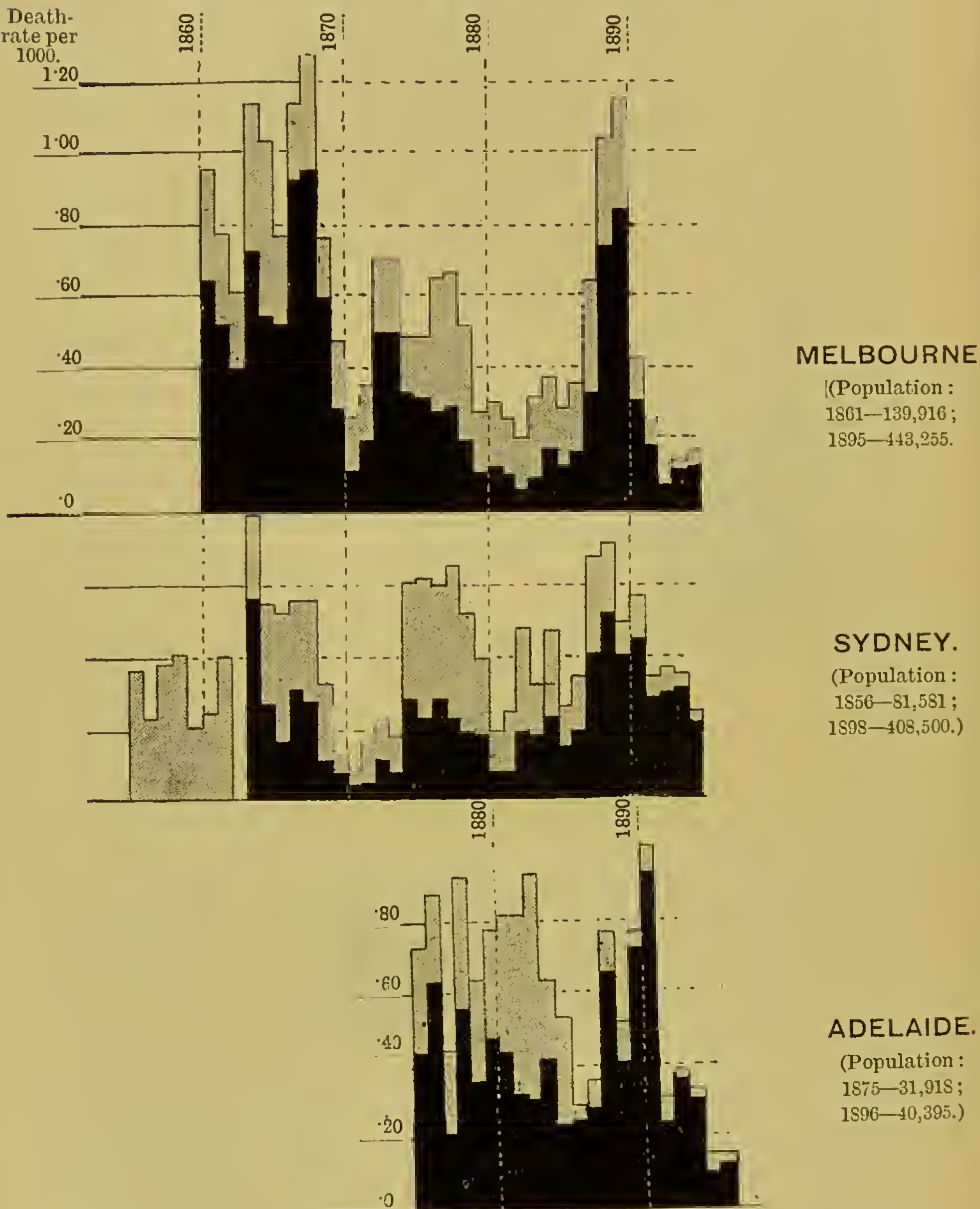


Fig. 42.

that a certain proportion of the cases of croup before 1858 were diphtheritic, and that the great increase of mortality from diphtheria and croup immediately afterwards did not represent solely deaths from a newly imported disease, though doubtless a large number of cases were imported.

According to the above report, diphtheria appears to have been in Tasmania before it was noticed in Victoria.

In *Queensland* (Fig. 41) a considerable epidemic culminated in 1873, which lasted with severity until 1877. A second epidemic reached its maximum in 1885.

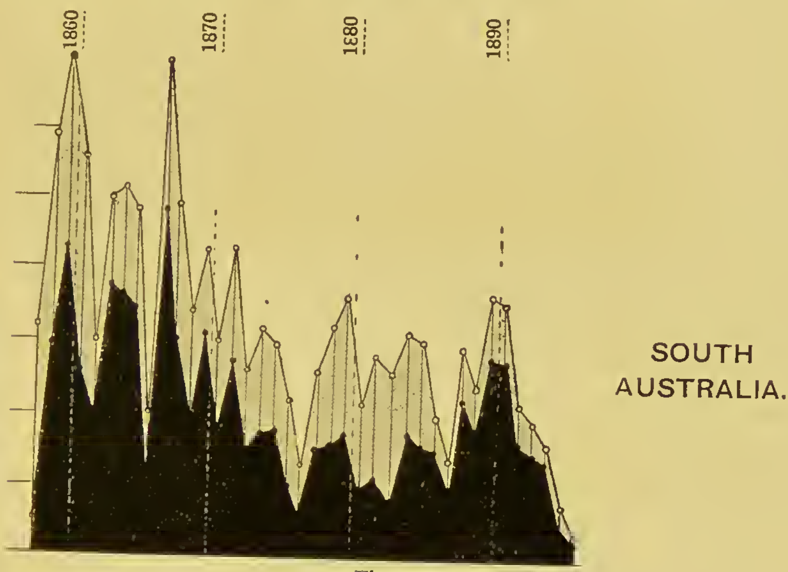


Fig. 43.

New South Wales, lying between Queensland on the north and Victoria and South Australia on the west, evidently suffered from the "early" epidemic of diphtheria, as shown by the table (top of page 100) quoted from the ninth annual report for 1866 of this colony:— "The first mention of diphtheria occurs in the report for the year 1864, but the disease had occurred to some extent during previous years, and had been tabulated as quinsy." *

* Quoted from "Age and Sex Incidence Mortality in Michigan, from Diphtheria and from Croup, during 25 years, 1870-94," by C.

Deaths registered in New South Wales, 1856–64.

Year.	Scarlatina.	Quinsy.	Diphtheria.	Croup.	Quinsy, Diphtheria, and Croup.*
1856	31	4	—	61	65
1857	38	4	—	38	42
1858	165	6	—	69	75
1859	120	50	—	85	135
1860	89	115	—	52	167
1861	70	153	—	74	227
1862	103	309	—	35	344
1863	95	51	239	142	432
1864	350	32	162	85	279

The curve for Sydney, the capital of New South Wales, shows that the early epidemic culminated in 1864, or possibly in 1863, as for the whole colony; but owing to changes made in nosological arrangement of tables, whereby diphtheria was included with other zymotic diseases, figures for 1863 are unobtainable. The acme was reached several years earlier than in Melbourne, in which it was not attained until 1868. The next epidemic was rather later, but more continuous, in Sydney than in Melbourne; while the most recent epidemic was a year earlier in reaching its maximum in Sydney than in Melbourne.

For the valuable and very complete statistical returns, represented in Figs. 44–47, I am indebted to my friend Mr. George Leslie, assistant actuary to the Government of New Zealand, who has given himself enormous trouble to secure them for me. They are particularly full, and

L. Wilbur, M.D. (*The Journal of American Medical Association*, Aug. 15, 1896).

* The last column, added by me, probably gives the truest conception of the progress of the epidemic, though it may be that some additional transference from the heading "Scarlatina" would be necessary to ensure accuracy. The maximum was reached in 1862–63, as compared with 1860 in South Australia and Victoria.

have a special interest in the marked contrasts between their experience and that of Australia. The records begin in 1872. Fig. 44 shows that in that and the two following years diphtheria was epidemic in New Zealand. A study of the details for individual districts shows that the chief brunt of the epidemic fell upon the districts of Auckland in the North Island, and Canterbury in the South Island, occurring later or remaining entirely in abeyance in the other districts. In some of these districts diphtheria, as a fatal disease, entirely disappears

NEW ZEALAND.

(Population: 1871—266,986; 1896—714,162.)

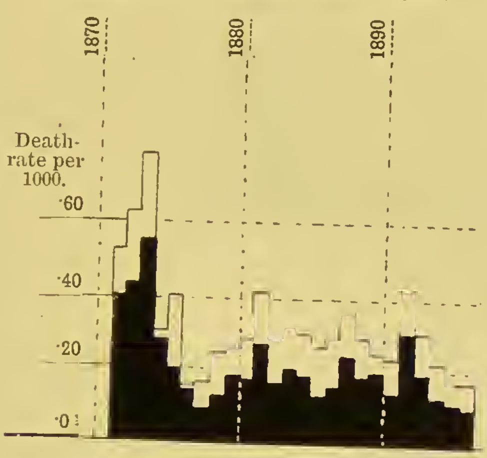


Fig. 44.

in the intervals of epidemics. Diphtheria is evidently not a disease of virgin soil, but follows in the wake of aggregated human communities. The contrast between Canterbury and the other districts is further commented upon on page 154. The diagrams, so far as further details are concerned, tell their own story.

NOTE.—Through an oversight, in Figs. 44-47 the parts of the diagrams relating to croup are not stippled as in all the preceding diagrams.

NEW ZEALAND. (A) North Island.

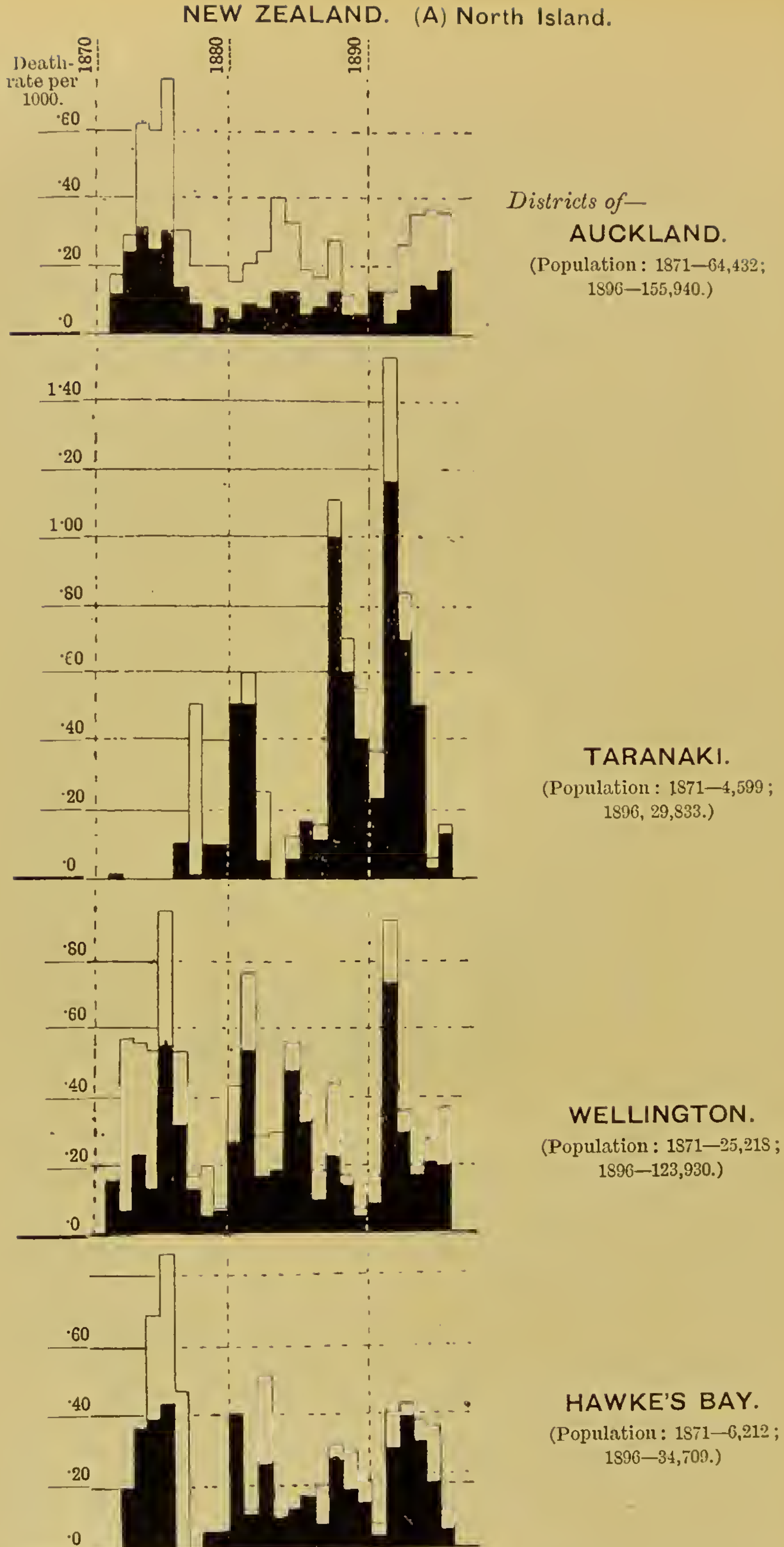


Fig. 45.

NOTE.—The record begins in 1872. No deaths from diphtheria or croup were registered in Taranaki in 1884, or in Hawke's Bay in 1872–73 and in 1878.

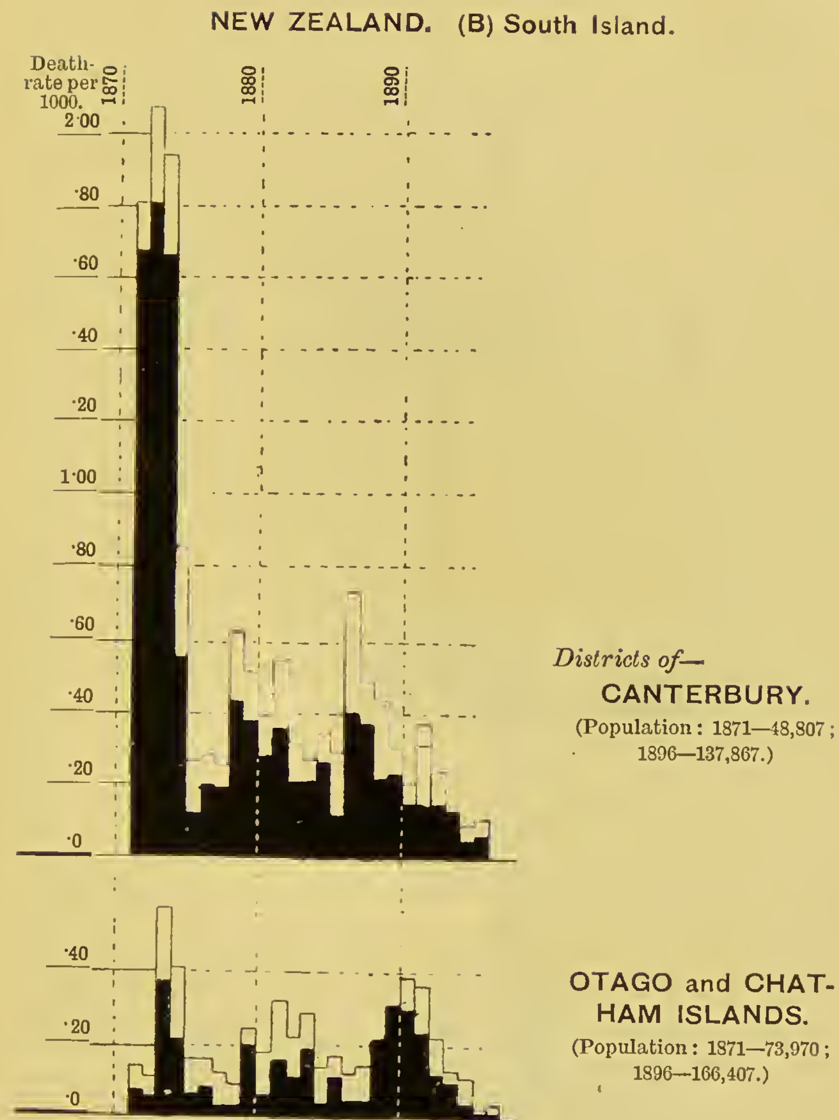
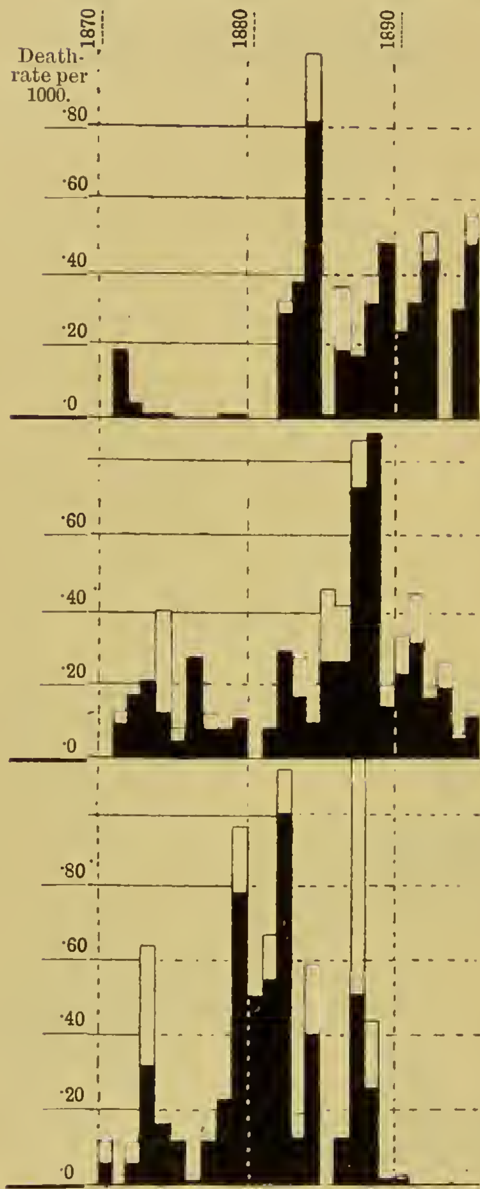

NEW ZEALAND. (B) South Island.
Death-rate per 1000.
1870
1880
1890
2·00
·80
·60
·40
·20
1·00
·80
·60
·40
·20
·0
·40
·20
·0
Districts of—
CANTERBURY.
(Population: 1871—48,807; 1896—137,867.)
OTAGO and CHATHAM ISLANDS.
(Population: 1871—73,970; 1896—166,407.)

Fig. 46.

NEW ZEALAND. (B) South Island, *continued*—



Districts of—

MARLBOROUGH.
(Population : 1871—5,385 ; 1896—12,677.)

NELSON.
(Population : 1871—23,042 ; 1896—36,201.)

WESTLAND.
(Population : 1871—15,381 ; 1896—14,598.)

Fig. 47.

CHAPTER XI.

RELATIONSHIP BETWEEN PREVALENCE OF AND MORTALITY FROM DIPHTHERIA.

It has been already mentioned that in Norway and Denmark there is a national system of registration of sickness.* From the data based on the records thus accumulated since 1860, in the case of Norway, and since 1855 for the capital of Denmark, the following curves have been constructed. In order to bring out the exact relationship between sickness-rates and death-rates, these have been calculated in terms of their deviation from the mean rate for the entire period. The mean annual sickness-rate from diphtheria for Norway in the period 1860–91 was 2·25 per 1000 of population; the mean annual death-rate ·40 per 1000. In Copenhagen the mean annual sickness-rate for the years 1855–95 was 5·88 per 1000, the death-rate ·78 per 1000.

The curves for both Norway and Copenhagen show a remarkably close relationship between prevalence and mortality. In the recent epidemic in Norway, the fatality (case mortality) evidently increased during the epidemic years, but this was not so in the earlier epidemic. There is some evidence of greater fatality during the greater part of the inter-epidemic period.

In Copenhagen, during the epidemics culminating in

* For further details, see a paper by the author, on "A National System of Notification and Registration of Sickness." *Journal of the Royal Statistical Society*, vol. lix., part i. (March, 1896).

1865 and in 1879, the fatality of the disease increased; but during the epidemic culminating in 1890, the cases increased in a slightly higher proportion than the deaths.

The relationship between prevalence of and mortality

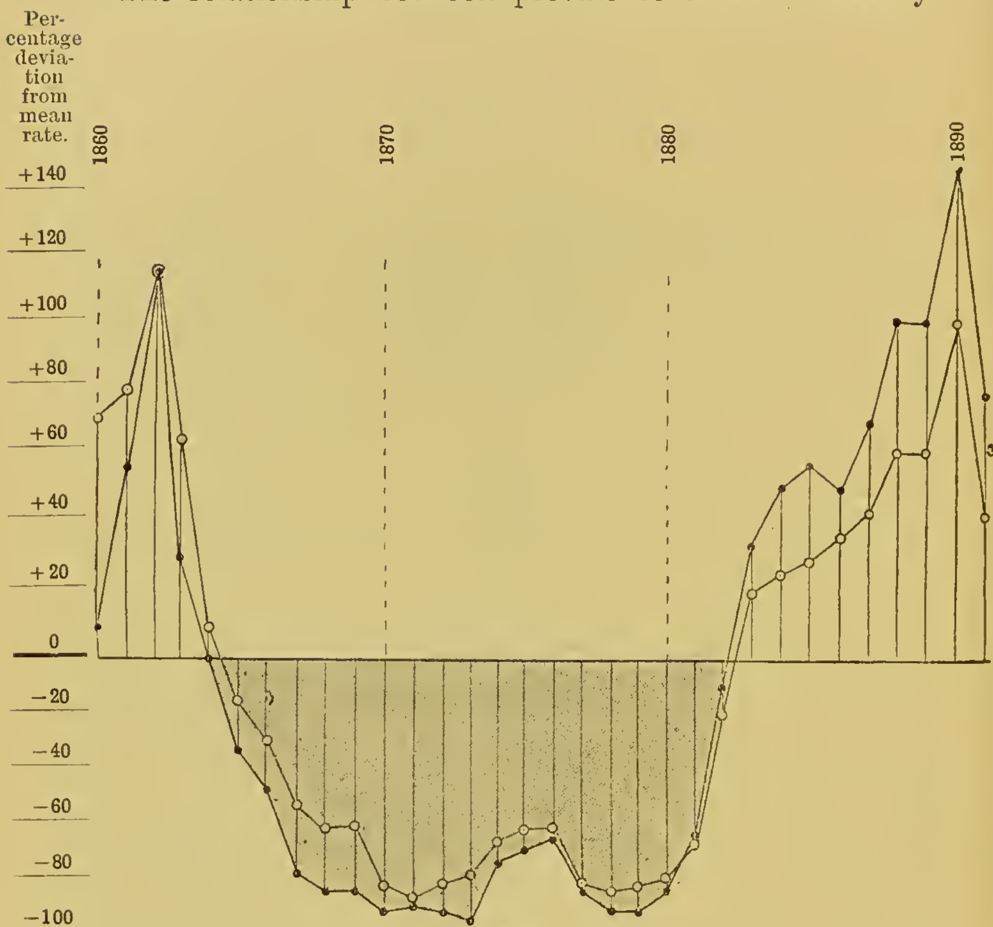


Fig. 48.

NORWAY.—Annual deviation of the sickness-rate (o—o—o—o) and death-rate (●—●—●—●) caused by diphtheria from the mean rate for the entire period 1860–1891.

from diphtheria may also be considered for Berlin, Hamburg, and London.

In Berlin during the years 1885–96, for which the comparable data are available, the average case-rate from diphtheria was 3·25 per 1000, varying from 2·16 in 1891 to 5·97 in 1885. Fig. 50 shows some increase of fatality in the earlier years of least prevalence of diphtheria in

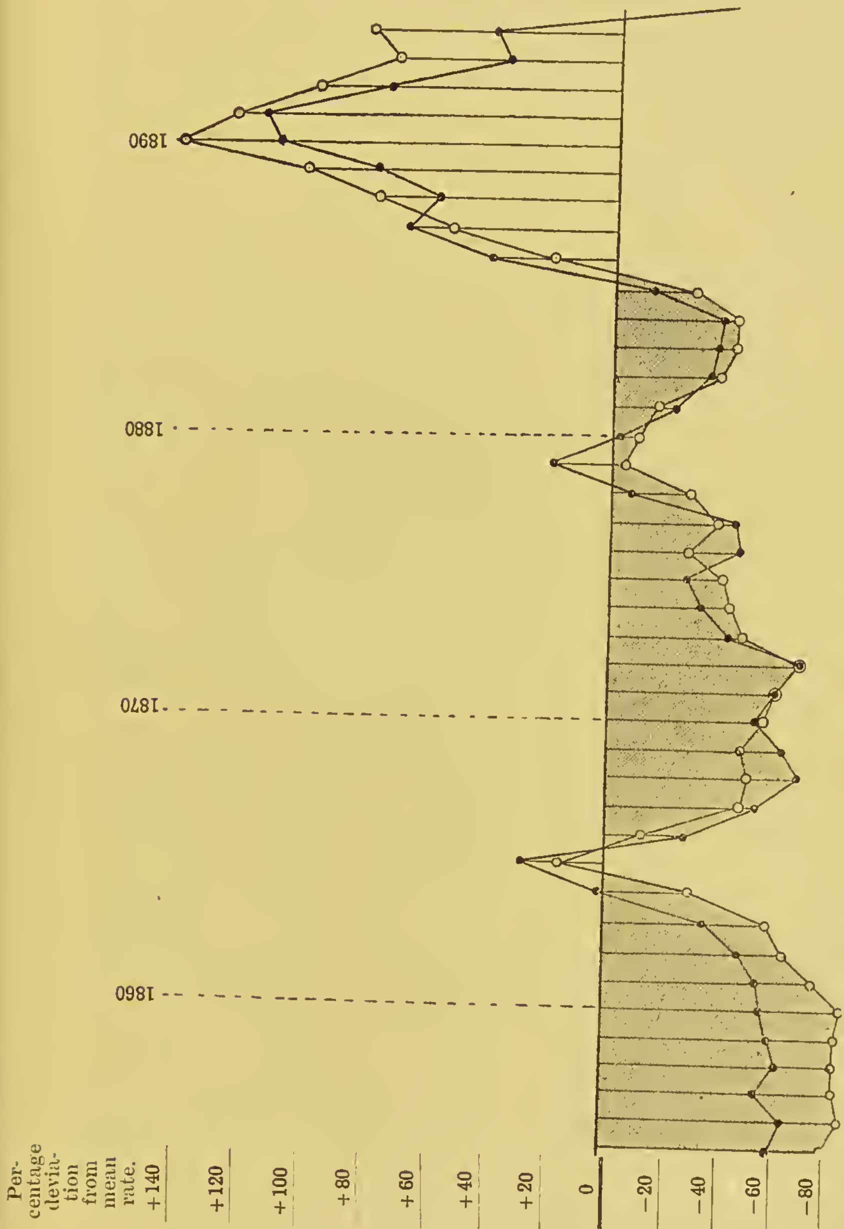


Fig. 49.

COPENHAGEN. — Annual deviation of the sickness-rate (o—o—o) and death-rate (●—●—●—●) from the mean rate for the entire period 1855-94.

Berlin (*i.e.* in 1889–93). In the most recent years this is not so, and it is probable that the disturbing influence of the treatment of diphtheria by antitoxic serum is to be seen in this change of fatality. Fig. 50 also shows for the years during which notification has been compulsory in London (beginning with the first complete year of notification, 1890), a close relationship between prevalence and mortality.

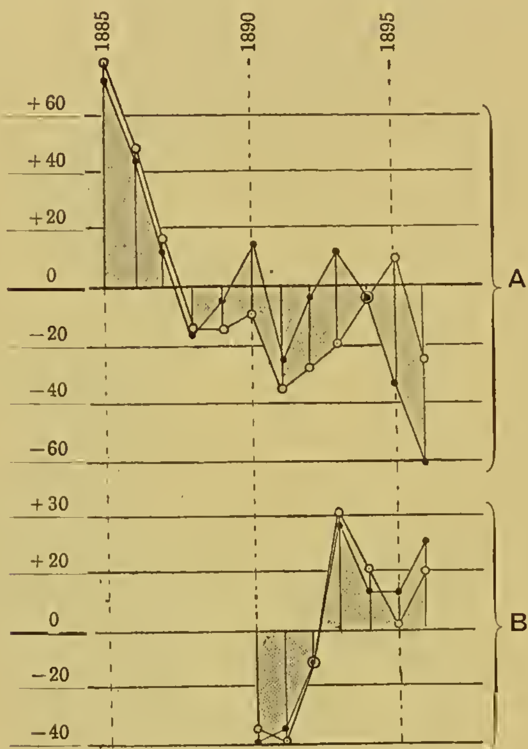


Fig. 50.

(A) BERLIN. (B) LONDON.—Annual deviation of the sickness-rate (o—o—o—o) and death-rate (●—●—●—●) caused by diphtheria from the mean rate for the entire period.

In the statistical reports for Hamburg the fatality from diphtheria *plus* croup is given for a long series of years. Beginning with 1872, and ending with 1896, the annual percentage fatality has been as follows :—

16·0, 17·6, 19·9, 17·8, 17·6, 13·3, 15·0, 12·5, **14·3,** 12·7, 13·0, 13·8, **15·9, 16·1, 17·0, 16·7,** 17·0, 15·8, 16·4, 14·6, 15·9, **15·2, 15·1,** 8·6, 8·4.

A study of these figures in connection with the epidemic curve for Hamburg (Fig. 29), shows that the fatality was greatest during the years of greatest epidemicity, while in portions of the Berlin and Scandinavian curves the experience is the reverse of this (Figs. 48–50). The years of greatest prevalence of diphtheria at Hamburg are indicated by using thicker type for the percentage case-mortality in these years.

The preceding figures and diagrams have an incidental utility on which some stress may be laid. They confirm my confidence in the general trustworthiness of the diagrams of death-rates scattered throughout this book. The more these are examined, the more, I believe, they will be found to tell the truth in all essential particulars.

NOTE.—On page 4 it is stated that there has been in the last few years in England a tendency to notify as diphtheria, cases which would previously have escaped notification. This remark was based on an impression as to the working of the Infectious Disease (Notification) Act, 1889, which is, I believe, shared by the majority of medical officers of health. Fig. 50 B, however, shows that this cause of error, if in operation at all, does not appreciably vitiate the statistics of large communities. In 1897, the cases of diphtheria notified in London were 12,811 as compared with 14,224 in 1896, giving a fatality of 17·7 as compared with 18·9 per cent. Thus in 1897, diphtheria in London declined both in amount and in fatality.

CHAPTER XII.

SUMMARY OF THE HISTORY OF DIPHTHERIA.

The following summary of the history of diptheria is derived from Hirsch's classical work, and from a number of French, English, and American writings, the different outbreaks being placed in chronological order. Owing to the difficulties of nomenclature, there is some difficulty in recognising diphtheria in the early accounts of "ulcerous sore throats" or "angina maligna"; but in the majority of the instances here cited, it is probable that diphtheria is the disease which is mentioned.

The summary is by no means complete. It would have been easy to double its bulk by including all the references in old medical literature; but sufficient has been given to indicate the widespread and virulent character of the disease before exact statistical records were kept.

Only a few instances of epidemics during the last forty years have been given, and these have been, as a rule, selected from districts in which statistical data are deficient. The diagrams already given sufficiently indicate the widespread character of diphtheria during these forty years.

A.D.

380. Macrobius speaks of an epidemic at Rome in connection with which sacrifices were offered up to a certain goddess—"ut populus Romanus, morbo, qui angina dicitur promisso voto, sit liberatus."

856. Baronius writes (*Annal. ecclesiast.*) of a "pestilentia faucium, qua fluxione guttur obstructum citam mortem inferret," as having occurred at Rome.*

1004. A similar epidemic is mentioned: "Catarrhus descendens in fauces, meatus obstruens, suffocatos miseros homines confestim mori cogebat." †

1039. Cedremus records an epidemic sickness known as κυνάγκη, which was prevalent in some provinces of the Byzantine Empire, and was very fatal.‡

1337. A fatal epidemic of sore throat occurred in Holland.

1389. Short refers to a kind of angina prevalent in England, which was fatal to a large number of children.§

1515. Herrera described diphtheria of the skin and of wounds, and looked upon the pseudo-membrane he found after death as the essential characteristic of the disease.||

1517. Hecker, in his account of the sweating sickness in England in 1517 (*Epidemics*, p. 224) describes "a malignant and infectious inflammation of the throat," which was often fatal within a day. This appeared in Holland, and later in the same year in Basle, "where, within eight months, it destroyed about 2,000 persons."

A similar outbreak is described by F. Von Word in the Rhine districts, in which "men's tongues and throats were covered as with a fungus, and turned white, etc."

* Quoted by Hirsch, vol. iii., p. 73–4.

† *Ibid.* ‡ *Ibid.*

§ Quoted by Webster, *History of Epidemic and Pestilential Diseases.* Hartford, 1799, i., 143.

|| Quoted by Jacobi, *Treatise on Diphtheria.* New York, 1880, p. 2.

1557. A similar very fatal epidemic in Holland, which spread to other parts of Europe. (Petr. Forestus, obs., lib. vi., *de febribus publice grassantibus,* et lib. xv. obs. 5–11.)

1563–64. A similar epidemic in Naples and in Sicily, which reached Constantinople and Alexandria in 1564.

1565. A pestilential angina described at Dantzig, Cologne, and Augsburg.

1576. A very malignant form of angina prevailed in Paris. Baillou mentions the finding of the false membrane at an autopsy by a surgeon whose name is not given, and describes its characters. (*Ballonii opera omnia, Epid. et Ephemer,* lib. xi., 1576. Geneva.)

17th Century. Early in the century an epidemic of angina in Spain, known as "garotillo," commenced apparently about 1583, and was still prevalent in 1618. It occurred at Spain later in the century; thus 1630 (Saragossa), 1645–6 (Alaejos), 1666 diffused.

1608. Mercado, the Sevillian poet and historian, tells of a child communicating the disease to its father by biting his finger.*

1610. A outbreak similar to that in Spain occurred in Mantua and Lombardy.

1618. The same disease appeared in Naples, and was known as "male de canna," disease of the trachea. It raged here more or less for twenty years. A full account of this is given by Carnevale in his treatise *De Epidemico Strangulatione Affectu.*

Between 1618 and 1642 it was generally diffused throughout Italy.

Quoted by Jacobi, *op. cit.*, p. 2.

1626. Portugal first visited by angina maligna in this year.

1632. Alaymus published a treatise on "Syrian Ulcers," evidently the same disease as that described by Carnevale.

18th Century. From the middle of the 17th century up to 1740, there is but little mention of the prevalence of malignant angina; but in 1701 it appeared in the Ionian Islands, and in 1715 in Aquilar de Campos (Province of Valencia).

1743–50. In 1743 angina maligna appeared in Paris, where it prevailed until 1750. Chomel described cases of diptheritic paralysis in connection with this epidemic. (*Dissert. hist. sur l'aspect du mal de gorge gangreneux, etc.* Paris, 1749.)

A similar epidemic appeared in England and in Cremona, N. Italy, about the same time. The English epidemics of angina maligna were described by Fothergill.

1743. An epidemic was noted in Ireland by Molloy.

1746. An epidemic at Bromley, England (Fagge).

1747. Ghisi describes an epidemic appearing in Cremona, which produced death by suffocation. At Orleans, Arnault describes cases of malignant sore throat fatal within twenty-four hours.

An epidemic at Greenwich (Fagge).

1749. At Liskeard, in Cornwall, an epidemic of malignant ulcerous sore throat appeared, of which Dr. Starr contributed a description to the *Philosophical Transactions.* He fully described the false membrane, including its extension to the larynx; and, in fact, anticipated Bretonneau's description of diphtheria. About this time appeared Fothergill's *An Account of the Sore Throat.* (London, 1748.)

1752. An epidemic was noted in New York by Father Middleton. A severe outbreak in Simmenthal (Switzerland) in the same year.

1753. An epidemic at Zurich (Langhaus).

1757. Huxham described an English epidemic, closely associated with scarlet fever. This appears to have prevailed more or less from 1751–53.

1758. Angina maligna seen again in Paris; also in 1759 and 1762.

1761. Rosen described an epidemic of cynanche maligna in Sweden, apparently beginning in 1755.

1765. Dr. Home's treatise on croup was published at Edinburgh. He showed that the formation of a false membrane in the larynx and trachea is essential to the disease.

1769–70. Kittel observed an epidemic in Utrecht associated with croup.

1771. Dr. Bard described an epidemic of suffocative angina appearing in New York in this year. In the same year Crawford, in Scotland, brought out a dissertation. (*De Cynanche Stridula.* Edinburgh, 1771.)

1774 and 1787. Angina maligna prevalent in some Norman towns and at Poictiers.

19th Century. At the beginning of the 19th century angina maligna retired into the background as an epidemic disease; so much so that in 1855–60, when it again became widely prevalent in Europe and North America, experienced observers regarded it as a new disease. France was an exception to this rule.

1801. Epidemics of angina maligna at Marienwerder and several places in East Prussia.

1805. Epidemic of angina maligna at Padua.

1816. An epidemic of the same in Crete.

1817–25. An epidemic of malignant sore throat in Kent in 1817, at Glasgow in 1819 and 1825, and at Kelso in 1825.*

1821. Diphtheria appeared for the first time at Lima; afterwards to a limited extent in 1850 and 1855, and again broke out in 1858. The black races proved as resistant to diphtheria as they were to yellow fever.†

1834. Epidemic of angina maligna at Skien, in Norway.

1835. An epidemic of malignant sore throat at Lisbon.

1810–11. Angina maligna was prevalent at Lyons.

1818–21. The well-known epidemic described by Bretonneau occurred at Tours.

1824–25. Epidemic at La Ferriere.

1826. Epidemic prevalent in Geneva and Canton Vaud.

1825–36. The disease became widely prevalent in France, particularly in the north-west provinces.

1818–21 and 1825–26. Term "diphthérite" originally used by M. Bretonneau in his treatise on the subject, which appeared in 1826. His treatise was based chiefly on epidemics of malignant sore throat in Tours and its neighbourhood in 1818–21, and again in 1825–26.

The report of the *Lancet* Sanitary Commissioners, 1859, states that, "while in the year 1825, a year remarkable for its extreme dryness, the communes

* The Kent outbreak occurred at Ashford. It is mentioned by Dr. Burdon Sanderson as "an epidemic of malignant sore throat, which proved extensively fatal to children, was never accompanied with any eruption, and differed from scarlatina." (Thorne, *Natural History of Diphtheria*, p. 15.)

† Quoted in Dr. Babington's Presidential Address (*Transactions Epidemiological Society*, vol. i., part i., p. 9), who refers to Hays's *American Journal*, vol. xxiv. p. 521, for a statement as to the gradual spread of the disease to Lima from the north.

north of Orleans were laid waste by diphtheria, it made as many victims in the damp and warm year, 1828, in the country south of Orleans."

1838 and 1849. Dr. Hoskins, of Guernsey, stated: "It is my firm conviction that the scarlatina epidemics of 1838 and 1849 had a diphtheric character, although the throat was not so decidedly affected as it was in 1820" (when he states that scarlet fever was very fatal in the island, "being accompanied by that peculiar inflammation of the throat, called by Bretonneau diphthérite").

1841. Becquerel described an epidemic of diphtheria in the Children's Hospital at Paris. (*Gazette Medicale de Paris*, 1843.)

1848–49. Cases of diphtheria observed in St. Thomas's Hospital, London; in Herefordshire, in Staffordshire, and near Yarmouth.*

1849. According to Netten Radcliffe, the first epidemic in this century in England was in 1849–50, in Pembrokeshire. ("On the recent Epidemic of Diphthéritis," *Lancet*, 1861.)

1850. In October of this year, Dr. Bennett read a paper before the Medical Society of London, detailing cases of undoubted diphtheria in his practice during that year (? in London).†

Diphtheria was epidemic in Norway.‡

1851. Dr. F. J. Brown, of Chatham, described cases of diphtheria at Rochester in 1851; again in 1852, '53, and '54.§

1853. Diphtheria appeared in Moscow, and was epidemic

* Quoted by Netten Radcliffe (*Transactions Epidemiological Society*, vol. i., part iii., p. 328).

† *Op. cit.*, p. 35. ‡ *Op. cit.*, vol. i., part iii., p. 333.

§ *Transactions Epidemiological Society*, vol. i., part i., p. 33.

in 1855. At the same time it was observed as the most prevalent throat affection of the French army in the Crimea.

An epidemic of diphtheria among the military at Avignon.

1854. Three cases occurring in an isolated house ten miles from Colchester were described.*

1854. Diphtheria broke out in Canton Zurich.

1855. A very virulent epidemic of diphtheria in Paris.

1855–56. The second epidemic in England began (Radcliffe) in Cornwall. At Launceston it began 30th September, 1855, coming to a height in August, 1856. In 1856 more numerous epidemics occurred. Several deaths near Spalding, Lincolnshire, in 1858. The disease appeared in Kent, November, 1856.

1855–57. From early in 1855, to March, 1857, a very virulent epidemic in Boulogne, killing 366 persons, including many English.

1856. Diphtheria first appeared in Iceland, breaking out first in Reykjavik, the point of communication with Europe, and thence spreading northward and westward.

1857. The relation of albuminuria to diphtheria was first observed by Dr. Wade, of Birmingham (*Midland Quarterly Journal of Medical Sciences*, 1857), and shortly afterwards in Paris, by M.M. Bouchut and Empis.

1858. An epidemic of diphtheria occurred in the rural parish of Hertingfordbury, Herts, beginning in October and suddenly ceasing at the end of the year. There were 53 attacks (14 fatal) in a population of 750. The outbreak is described by Dr. Burdon

* *Op. cit.*, p. 35.

Sanderson (*Epidemiological Society's Transactions*, vol. i., part i., p. 61), and appears to have arisen under circumstances rendering importation of the infection improbable.

1859. In 1859 diphtheria had become general throughout England.

1861. Diphtheria made its first appearance at Phthlistes (Hellas).

1862. An epidemic in the first quarter of this year in the Commune de Ceyret (Puy-de-Dome).

1863. A severe epidemic in the arrondissement de Montbeliard (out of 77 patients 17 died).

A very fatal epidemic, October, 1863, to end of 1865, at Louhaus (Saône-et-Loire). Of 2,500 cases 397 died.

1864–67. Leopold Graf (*Deutsche Klinik*, 1868) gives statistics of 24 cases at Munich, of which 7 were fatal.

1865. An epidemic ravaged the Communes of Fabreges and Saussau (mid-France) from September, 1865, to February, 1866.

In the same year an epidemic raged in the arrondissement of Blaye, and it was noted that the first patient was a sick stranger who had brought diphtheria with him, while the second was a girl in the same house (quoted in the *Dictionnaire Encyclop. des Sciences Medicales*, tome xxix., p. 639).

1865. Diphtheria is said to have first appeared in Smyrna.

1865–66. A small epidemic at Schorndorf in Wurtemburg (66 patients, 23 deaths).

The deaths at Pekin in this winter from diphtheria were estimated at 25,000.

1866. Becker described an epidemic in Hanover, attacking 155 inhabitants out of 487, and killing 29. Similar outbreaks in Kiel, etc.

1866. Lange (in *Journ. fur Kinderkrankheiten*, 1869) described the increasingly epidemic character of diphtheria in Denmark. Thus in—

1861	550 cases.
1862	1,220 ,,
1863	2,304 ,,
1864	5,987 ,,
1865	121,826 ,,

(see also Fig. 40).

1866. A wide epidemic in Kaffraria, described by Lewson (*Transactions Epidemiological Society*, 1869).

1868. Diphtheria is said to have first appeared in Roumania, spreading to Turkey, etc.

1869–70. At Bucharest, Professor Felix describes an epidemic, in which 200 out of 415 patients died. It is noted that the Jewish population of 1,400 almost entirely escaped, probably owing to their comparative isolation in their quarters.

1871. A grave epidemic at Thoury (Loir-et-Cher). Of 21 patients, 16 died. Similar epidemics at Saint Laurent de la Prée (Charente-Inferieure), at Vienna (Isère), etc.

1872. Several epidemics in different parts of France.

1875. Dr. Sainton describes an epidemic in the three communes of Bar-sur-Seine, Celles-sur-Ource, and Mussy-sur-Seine (Aube), lasting from 20th November, 1874 to the end of 1875. Out of a total of 5,203 inhabitants, 628 were attacked, and 80 died; the

NOTE.—An excellent account of the History of Diphtheria in Denmark and Germany is given by Dr. J. Carlsen, of Copenhagen, in *Janus*, i. pp. 48, 161, and ii. p. 1.

mortality among boys was $\frac{1}{5}$, among girls $\frac{1}{6}$, and among adults $\frac{1}{18}$. Several other outbreaks, 1874–75, in France (described in *Dictionnaire Encyclop. des Sciences Medicales*, p. 642, tome xxix.).

1875–76. An epidemic at Veroli, province of Frosinone (Italie). In the same year an epidemic in Tunis.

1876. Yeats describes ("On an Outbreak of Diphtheria in Auchtergaveny, Perthshire, with Remarks," in *Edinburgh Medical Journal*, July, 1876) a severe epidemic lasting from March, 1875, to end of June. Out of 1,500 inhabitants, 183 were attacked. Several months previously there had been several fatal cases of croup in a village ten miles to the south-west.

1877. Diphtheria became epidemic at Yokohama.

1879. M. Droumoff (*Thèse de Paris*, 1879) describes an epidemic in Roumania, in the district of Braila.

1881. Epidemics of diphtheria at Sourabaya and Batavia, in Java.

1881–82. Diphtheria again epidemic at Yokohama.

Special History of Diphtheria in America.

1736. Dr. Douglas, of Boston, published an account of the first appearance of a "sore throat distemper" in this country.*

Dr. Fothergill, in the first vol. of *Medical Observations and Inquiries*, vol. i., p. 211 (London, 1771), gives an extract from a letter from Mr. C. Colden, dated Coldenham, New York, October 1, 1753, in which he states that the throat distemper first appeared at Kingston, an inland town of New England, about

* Dr. Douglas' treatise is entitled *The Practical History of a New Epidemical Eruptive Miliary Fever with an Angina Ulcusculosa, which prevailed in Boston, New England, in* 1735 *and* 1736. Probably there were mixed cases of scarlet fever and diphtheria.

1735, gradually spreading westward, and not reaching Hudson's River till nearly two years afterwards. "It continued on the east side of Hudson's River before it passed to the westward, and appeared first in those places in which the people of New England resorted for trade, and in the places through which they travelled."

1752. An epidemic of malignant sore throat noted in New York by Father Middleton.

1771. Dr. Bard described an epidemic of sore throat in New York, characterized by false membrane, etc. He emphasizes the difficulty in detaching the false membrane found post-mortem in the trachea.* He also contrasted the sudden onset of scarlet fever with the drooping in diphtheria, and speaks of a "few white specks on the tonsils, which in some increased so as to cover them over with one general slough."

1809. Epidemic of malignant sore throat at Philadelphia.

1826. Epidemic of malignant sore throat at New York, Salem, and Danville.

1831. An epidemic in Philadelphia, in 1831, similar to the one described by Dr. Bard.

1836. An epidemic of malignant sore throat at Orizaba, in Mexico.

1855. Dr. Wynn mentions epidemics at Lima, in 1855 and 1858. (A Paper on Diphtheria. New York, 1861.)

1856. A terrible epidemic occurred in San Francisco, and in other towns of California ; on which Dr. J. V. Fourgeand published a monograph.

* Dr. Bard's treatise on Angina Suffocation was published in 1771. In 1810 it was republished in Paris, and was known to Bretonneau, who quoted from it.

1858. Diphtheria epidemic in Albany, N.Y., in 1858. There were 167 deaths in a population of 60,000.

The following figures relating to Philadelphia are quoted by Mr. Thomson (see page 96) from the treatise by Professors Meigs and Pepper:—

PHILADELPHIA.

Year.	Number of Deaths from		
	Scarlet Fever.	Diphtheria.	Croup.
1855	163	—	265
1856	992	—	268
1857	704	—	256
1858	241	—	292
1859	232	—	312
1860	206	307	354
1861	329	502	304
1862	461	325	258
1863	275	434	444
1864	349	357	455

This is quoted by Mr. Thomson as an indication that in Philadelphia, as in Melbourne, diphtheria was a newly imported disease in 1858–59. It cannot be accepted as such, in view of the preceding historical facts, but it is valuable as indicating the date of maximum of the "early" epidemic ("early" so far as statistical data are concerned) in Philadelphia.

SPECIAL HISTORY OF DIPHTHERIA IN NORWAY.

For the facts of the following summary, dealing with the history of diphtheria in Christiania in this century prior to 1865, I am indebted to the great kindness of Dr. Bentzen, the Medical Officer of Health of Christiania. He tells me that it was compiled many years ago from unprinted medical reports by the Medical Officer of Health. The facts are given almost in the exact words of the English translation made by Dr. Bentzen's assistant.

This exact record is necessary, in view of its important bearing on the climatic question (see page 148.)

Angina Membranacea (Croup) in Christiania.

1833. Angina trachealis, a comparatively rare disease in Christiania, killed several children this year.

1834. At the beginning and end of this year a larger number of children were carried off by this illness than in the last two years.

1845. In the months of July and August some children were attacked.

1846. Specially in January, and in the latter half of the year, several even older children were attacked, usually with a fatal issue.

1847.

Angina Membranacea (Croup).	*Diphtheria.*
Continued from last year among both younger and older children, but seemed to decrease as measles became more frequent, though it appeared now and then throughout the year, more frequently at its end, although probably not as fatal as before.	Appeared occasionally, specially during the autumn months.

1848.

Attacked some children during the year, but seemed not to be so fatal as before.	Some persons, adults and children, were attacked in the first and last part of the year.

Christiania.

1849.

Angina Membranacea (Croup).	*Diphtheria.*
Reports are missing.	Reports are missing.

1850.

Both diphtheria and croup attacked several, both adults and children, but were not very fatal. (See also note on page 116.)

1851.

Appeared sporadically, and claimed some victims.	Attacked several adults and children, specially during the autumn and in the first months of the year.

1852.

Appeared sporadically. Some cases died.	Appeared now and then, but seldom and only sporadically, in adults as well as children; was not very dangerous.

1853.

Carried off some children, especially about the end of the year.	Angina faucium was common in the first months of the year, during the epidemic of cholera, and was often of an exudative nature. Before this was most frequently of an ordinary character.

1854.

Appeared only quite sporadically.	Inflammations of the throat with exudates appeared now and then.

CHRISTIANIA.

1855.

Angina Membranacea (Croup).	*Diphtheria.*
Was rare; three cases are stated to have died of this illness.	Now and then all the year round, but only sporadically, inflammations of the throat of an exudative nature appeared. They were but seldom fatal.

1856.

Appeared in single cases in the autumn, coincident with catarrhal affections.	Appeared singly, not frequently nor malignant.

1857.

Was in this year more frequent than in the preceding, and is notified in all months of the year except February, July, and August. Most of the cases occurred in December. The total number of cases of which account exists was 10 in the city and 15 in the suburbs. Of these, 16 died.	Inflammation of the pharynx with exudates occurred all through the year, principally in the months of March and May. Five persons are stated to have died of diphtheria. Within one family, all the eight children were attacked in the course of two months.

1858.

Appeared frequently during the last four months of the year. In the National Hospital 17 were treated, of which 10 died. To the Medical Society 32 cases, with 24 deaths, were reported.	Appeared through the whole year, but principally about its end. To the Medical Society were reported 69 cases, of which 31 occurred in November and December. None of them died. One doctor has mentioned three deaths.

The following additional data are furnished by Dr. Bentzen :—

CHRISTIANIA.

Year.	No. of Notified Cases of		Notified Cases of Diphtheria *plus* Croup per 1,000 of Population.
	Angina Membranacea (Croup).	Diphtheria.	
1859	62	119	3·42
1860	53	124	3·30
1861	32	84	2·15
1862	23	285	5·65
1863	31	193	4·07
1864	29	163	3·43
1865	27	126	2·71
1866	27	74	1·83
1867	17	88	1·78
1868	21	82	1·67
1869	20	53	1·15
1870	17	81	1·51
1871	10	62	1·08
1872	10	48	0·85
1873	6	46	0·74

Notwithstanding the fact that in the early years the notification of cases was not so complete as it subsequently became, it is evident that in 1859, the year in which the record begins, a large epidemic of diphtheria was prevalent in Christiania, the number of cases in proportion to the population being larger in that year than in any of the subsequent years in the above table, with the exception of 1862, 1863, and 1864.

CHAPTER XIII.

INTERNATIONAL REVIEW OF THE PREVALENCE OF DIPHTHERIA AS SHOWN IN THE PRECEDING DIAGRAMS.

THIS review naturally divides itself into three parts—

(*a*) For the American Continent.

(*b*) For Europe.

(*c*) For Australasia.

In discussing the source and mode of spread of epidemics, the greatest difficulties necessarily arise in connection with cities like the American cities and the cities on the European continent, in which there is a *large mass of diphtheria constantly endemic.* The epidemics occurring under such conditions may be taken simply to represent intermittent exacerbations of the local infection, from an accumulation of susceptible persons, or more probably from an increased infectivity of the disease at intervals. Or they may be regarded as due to the importation of a new "strain" of disease; and there are not wanting, as we have already seen, indications of gradual spread from city to city and from district to district.

The following tabular statement of years of maximum epidemic prevalence in the chief cities in America from which records have been obtained makes this clear :—

Maximum Epidemic Years in America.

New York			1876–7–8	1880–1–2		1886–7–8		1893–4
Brooklyn			1875–6–7	1880–1		1886–7–8–9		1894–5
Philadelphia			1875–6	1881–2				1890–5
Baltimore				1881–2–3			1891–2	
Pittsburgh			1877–8–9–80		1884–5–6–7		1889–90–91	
Boston	1863–4		1875–6	1880–1			1889–90	1894
Providence			1877–8			1886–7–8–9–90		
Cincinnati		1868	1878–9			1886–7	1889–90–1–2	
St. Louis			1875–6–7–8	1882–3–4		1886–7–8		1895
Denver						1888–9–90–1		
Chicago	1860–1–3–5	1869–70	1876	1879–80–81		1886–7	1890	
Montreal			1877–8		1884–5	1887–8		
Buenos Ayres							1888–9–90	

Maximum Epidemic Years in Europe.

Christiania	1861–2 . . . 1885–6–7–8–9–90
Gottenburg	1861–2 . . . 1873–4 . . . 1883–4 . . . 1894–5
Stockholm	1862–3, '65 . . . 1881–5, '87 . . . 1891–4
Copenhagen	1846–7–8 . . 1852 . . 1864–5 . . . 1879–80 . . . 1886–7–8–9–90–1–2
The Hague	1884–5 . . . 1892–3
Rotterdam	1883–4
Amsterdam	1883–4 . . 1889–90–91
Antwerp	1859–60 . 1863–4 . . . 1882–3 . . . 1894
Brussels	1862–3–4–5 . . . 1884–5–6–7
Hamburg	1872–3–4–5 . . . 1885–6–7 . . . 1893–4
Berlin	1875–6 . . . 1882–3–4 . . . 1893
Dresden	1881–2–3–4, '86 . . . 1892–3–4
Leipsig	1872–3–4–5 . . . 1883–4–5 . . . 1892–3
Frankfort-on-the-Main	1851, '53, '58 . 1864–8 . . . 1873 . 1876–7–8–9 . . . 1887–89–90–1–2–3
Munich	1868–9 . . . 1880–1 . . . 1889–90
Prague	1865 . . 1870 . . . 1875, 1877–8 . . . 1886–7–8–9–90 . 1893–4
Buda-Pesth	1875, 1877–8 . . 1881–2 . 1885 1889–90–1–2–3
Trieste	1865 . 1869–70 . 1872–3–4 . . . 1881–2–4–5 . . . 1894–5
Paris	1865–6 . . . 1872–3, 1875–6–7, 1879–80–1–2 . . . 1888–90
Venice	1869 . . . 1875–6 . . . 1881–2 . . . 1890–1
Florence	1866–7 . . 1871–2–3 . . . 1879–80–1 . . . 1887–8
London	1858 . 1861–2–3 . . . 1875–6 . . . 1888–9 . 1892–3–4–5–6

The years of greatest epidemic prevalence in European towns and cities are shown in the tabular statement on the preceding page.

The chief epidemic years in Australasia are similarly tabulated below :—

MAXIMUM EPIDEMIC YEARS IN AUSTRALASIA.

Melbourne	1858–1861 .	1867–8 .	1873–4 . . .	1889–90
Sydney		1863–4 . . .	1875	1889
Adelaide			1876–78	1890–91
New Zealand			1872–4	1882 . 1888 . 1892

The evidence derivable from the diagrams, already fully discussed, and from the preceding imperfect tabular summary of their contents, abundantly justifies several important conclusions.

(*a*) Diphtheria tends to spread from place to place by the ordinary channels of communication. It is impossible in every instance to track the course of the pestilence. This would probably have been easier had it been practicable to plot out the quarterly instead of the annual mortality from the disease for each town. It is almost certain that its spread is not regular, that it radiates in different directions, and that the same city may at the same time in relation to other cities be both giving and receiving infection.

(*b*) There are certain years in which over whole countries, or even over more than one continent, diphtheria is at the same time epidemic. The possible causes determining these pandemics will be considered shortly.

(*c*) Remarkable differences will have been observed in the amount of diphtheria *endemically* present in different countries and cities. This amount is smallest in Ireland, next smallest in England and in New Zealand, then comes Scotland. In determining the relative amount in towns on the continent of Europe, there is the difficulty that many of them combine diphtheria and croup in their returns. It would appear, however, that Paris and Berlin occupy a supreme position as regards the amount of endemic diphtheria. Munich and Hamburg are not far behind, while in Brussels it is somewhat less fatal. Italian towns also suffer very severely. In Scandinavian cities there is a very great mortality from this disease; but it prevails chiefly in an epidemic form.

Turning to the American returns, it seems probable that in Boston, New York, Chicago, and Montreal, there is even more endemic diphtheria than in Berlin or Paris. A safer and more trustworthy impression of the actual amount can be obtained by a comparative survey of the diagrams than by a study of the average death-rates given in the tables on preceding pages.

(*d*) In places in which there is no large amount of endemic diphtheria the preceding diagrams show a distinctly *cyclic character* in the recurrence of the epidemics and pandemics.

(*e*) The *intervals* between these cycles vary greatly. They may be only three or four years. The Gottenburg curve is a good instance of an almost regular cyclic appearance of diphtheria at intervals of ten or twelve years. In Christiania the interval is much longer. In London, when diphtheria became very prevalent in 1858, it was thought to be a new disease. It did not become epidemic again until 1875, and then feebly; and it was not until 1893 that the third epidemic, of which statistical records are extant, culminated. New York shows epidemics culminating at intervals of four, six, and seven years respectively; Chicago shows epidemics culminating at intervals of five, fifteen, and six years. Other instances can be gathered from the diagrams.

(*f*) The cycles themselves extend over periods varying from a single year to six or even ten years. In large cities it is usually five or more years before the epidemic has worn itself out. In smaller towns the epidemic more quickly dies down. The recent epidemic in London is a striking instance of protracted duration of a diphtheritic cycle; and the "true inwardness" of this prolonged duration is understood when we refer to the detailed diagrams for London during this period, showing the relative prevalence of diphtheria in each separate district of London. From these it is clear that diphtheria gradually spreads from one district to another, and that in the course of the one great epidemic the same district in a great city may suffer epidemically more than once (see Figs. 23 and 24).

CHAPTER XIV.

ARE THERE INDIGENOUS FOCI OF DIPHTHERIA ?

THE series of diagrams clearly show that, although the amount of *endemic* diphtheria varies greatly in different countries, in no town from which records have been obtained is there a complete absence of the disease in a single year since the records commenced.* In all, therefore, diphtheria is an endemic disease. In several instances, as in 1873 in Christiania, 1891 in Gottenburg, 1876 in Prague, 1880 in Hastings, and 1867 in Perth, diphtheria almost disappeared. But as a rule a material amount of diphtheria remains endemic in all centres of population. It is perfectly legitimate to suppose that either (*a*) this local diphtheria is the source from which the epidemic diphtheria is derived, or that (*b*) the epidemic diphtheria is imported from the centres in which it is more extensively endemic. That there are *favourite endemic foci* for the disease is evident. Some of the great cities of America come under this head; so also do Berlin, Paris, and other cities on the European continent. So far as the last forty years are concerned, we are not, therefore, in a position to solve the problem as to whether epidemic diphtheria originates in certain indigenous foci, analogous to those for yellow fever and for cholera, or whether it represents the blazing up of the embers of diphtheria endemically present in nearly all the cities and towns from which records have been secured.

* Some districts of New Zealand (embracing towns) show a complete inter-epidemic absence of deaths from diphtheria. See charts, pages 102 and 104.

There are reasons for thinking that in some of its present endemic centres diphtheria was formerly prevalent only in epidemics at wide intervals. Thus in England prior to 1856–7 diphtheria appears to have been almost unknown for a generation. Probably it would be more correct to say *unrecognised,* for commingled with scarlatina anginosa, ulcerated sore throat, quinsy, croup, and cynanche tonsillaris, there must, I think, have been a considerable share of diphtheria. In France, according to Mons. A. Sanné (art. "Diphtheria," *Encycl. des Sc. Medicales.* Paris, 1884), diphtheria confined itself for a very long time to certain departments of the centre; it then became epidemic in Paris in 1842–3; and after this there was a long interval, the disease reappearing in 1855, and finally ended in becoming endemic, with frequent recrudescences.

CHAPTER XV.

INFLUENCE OF IMPROVED AND EXTENDED MEANS OF COMMUNICATION.

The increased facility and rapidity with which in recent years cholera has become pandemic has been the subject of frequent comment. The epidemics in Europe of 1832 and 1849 spread but slowly; while those of 1855 and 1866 spread with a rapidity previously unknown.

The "early" epidemic of diphtheria (1855–60) coincided with a considerable development of the means of locomotion in the whole of Europe; and it is not unlikely that this increased the rapidity and the extent of its spread. The same reason may explain why in so many cities diphtheria now remains constantly endemic to a very considerable extent.

The influence of *attendance of children at school* may receive a brief notice in this connection. Most physicians have experienced instances in which personal infection in connection with school attendance has caused outbreaks of diphtheria. Occasionally these are of considerable magnitude. Mr. Shirley Murphy, the Medical Officer of Health of the Administrative County of London, has shown that when allowance is made for the period of incubation of the disease, there is a marked fall in the number of cases of diphtheria notified for the three or four weeks embracing the August–September summer school holiday, the effect being most marked for cases at ages 3–13, the years of school attendance. It is, however, one thing to admit that school attendance in common with all other means of personal communication between susceptible persons (of whom scholars at elementary schools form a vast majority) is an important factor in determining the extent of the spreading of diphtheria, and another to attempt to explain, as some have done, the recent epidemic of diphtheria in England as if it were caused *chiefly* by the increased enforcement of compulsory school attendance.* Mr. Murphy is satisfied to show that *school attendance is a means of spread of diphtheria.* With that all must agree, and must further agree as to the urgent necessity for additional precautionary measures in connection with the close aggregation of children in our elementary day schools. Others, less judiciously, attempt to explain the entire or the greater part of the recent increase of diphtheria in England as due to school attendance. Such a notion will be corrected by looking at diphtheria from an international view-point. Notwithstanding its enforcement of compulsory school attendance since 1871, London even in its maximal epidemic year (1893) presents no more diphtheria in proportion to their respective populations than is constantly endemic in Paris or Berlin.

The writer has made personal enquiries of the respective public health officials of Christiania, Copenhagen, Stockholm, Berlin, and Hamburg, as to the degree and

* In the review of *The Annus Medicus*, 1897 (*Lancet*, December 25th, 1897), it is stated: "No one . . . can have watched the recent weekly returns of the Registrar-General as regards the metropolis without feeling that the waste of child-life which is going on in London is a matter calling for the most careful inquiry. Nearly every one who is conversant with the subject is convinced that the increase has taken place not only synchronously with, but consequent on, the increased aggregation of children at the most susceptible age for diphtheria in our elementary schools."

duration of enforced school attendance, with the following results :—

At *Copenhagen* school attendance is stated to have been "always" compulsory. There has been no increase of its stringency during the last fifty years.

At *Christiania* school attendance has been compulsory since the passing of the Act of 12th July, 1848; probably in a large measure earlier. Attendance is compulsory from the seventh year to confirmation, which is not allowed before fourteen years old. The age of compulsory attendance has never been altered.

At *Stockholm* school attendance has been compulsory for at least fifty years, and there has been no increased stringency of enforcement of attendance in recent years.

At *Berlin* school attendance is compulsory from six to fourteen, and has been so for about 100 years.

At *Hamburg* it has been compulsory for forty to fifty years.

Comparing these data with the incidence of diphtheria in the above cities, we find that at Christiania, Stockholm, and Copenhagen, there has been a very great increase of diphtheria since 1880, not associated with any increased enforcement of school attendance.

The Berlin and Hamburg curves show an increasing amount of fatal diphtheria in the earlier years of the curves, followed by a large decline during the present decennium. Thus the steady enforcement of school attendance has been associated with a declining amount of diphtheria in Berlin and Hamburg in recent years; in the Scandinavian cities the same steady enforcement of school attendance has been accompanied by an increase of diphtheria; while in London the enforcement (possibly incomplete in the early years) of school attendance since 1871, for thirteen years was not followed by any material increase of diphtheria, but subsequently a slow increase of mortality from diphtheria occurred, culminating in 1893 in a death-rate still well below the average diphtheria death-rate of most European cities. The only safe conclusion is that school-infection is only a minor cause of the spread of this disease: it forms but one incident in a battle, which by no means determines the issue of the entire campaign. In saying this, I am anxious to make it clear that I entertain very strong views as to the necessity for increased precautions in connection with the return to school of children who have been absent on account of illness of an ill-defined character. The strenuous efforts made by school-teachers and school-attendance officers cause the return to school of children who are undoubtedly a source of danger to their school-fellows, although they may not have had a recognisable attack of diphtheria. The machinery with respect to return to school of absentees requires radical change; and as this would imply additional medical help, and the free use of bacteriological diagnosis, a considerable increase of expense will have to be faced. Assuming that, as will be contended later, wider pandemic influences are at intervals of years in operation, over which we have little control, we are not justified in abstaining from every effort to minimise the action of these wider causes by preventing personal infection.

The relative amount of diphtheria in *urban and rural districts* has a bearing upon the question of the influence of freer inter-communication. When a sufficiently long series of years is taken, as in many of the preceding diagrams, it appears clear that there is more diphtheria in urban than in rural communities. This might have been expected, diphtheria being an infectious disease, and consequently increased by improved and extended means of personal communication. The validity of this conclusion can be tested by reference to the diagrams. Thus the whole of Michigan, which has a large proportion of rural population, has much less diphtheria than the neighbouring city of Chicago; the whole of Massachusetts has less diphtheria than Boston or New York; the whole of England less than London; the whole of Japan less than its great towns; the whole of South Australia less than Adelaide (comparing corresponding periods 1875–96 in Figs. 42 and 43).

CHAPTER XVI.

THE CONDITIONS DETERMINING THE PANDEMICS OF DIPHTHERIA.

Do the accumulation of a susceptible population of children and the accidental introdution of infection from without embrace the entire etiology of an epidemic of diphtheria? As regards susceptibility, any population containing an average proportion of children is a susceptible population; and it is doubtful whether a previous attack of diphtheria very greatly diminishes this susceptibility. It is not unlikely that one attack predisposes to another, as in rheumatic fever. Whether this is so or not, in view of the fact that *in all European and American cities diphtheria has been constantly endemic to a certain extent during the last forty years,* some further cause than the importation of infection is necessary, in order to explain why in certain years diphtheria becomes epidemic: and still more to explain why in certain years diphtheria becomes pandemic.

This further cause might conceivably be found in some alteration in the personal condition of a large proportion of the total population, rendering them more susceptible to the disease. For this explanation to suffice, it must be supposed to act over large continents in pandemic years, a supposition which breaks down under the weight thus imposed upon it. The more probable explanation is some change in the external conditions of life, and our search must be directed towards the most likely of these, which are meteorological and telluric.

The influence of these conditions in different countries will now be tested. It has been impracticable to insert more than a few diagrams illustrating these external conditions in relation to diphtheria; but although I have tested a considerable number of instances not here given, I have not found one which would necessitate a conclusion, so far as that particular place is concerned, contrary to the totally unexpected one stated in the following pages.

In London, there is evidence of an epidemic in 1847, a second epidemic in 1857–59 and 1861–64, a very slight epidemic in 1874–76, an increasing amount of diphtheria from 1884, culminating in an epidemic which obtained a firm hold of the metropolis in 1888–89, and after a slight remission for two years, became more extensive in 1892–96 (see Fig. 13, page 30).

Compare these facts with the rainfall for a long series of years at Greenwich. During the 55 years, 1841–95, the average annual rainfall at Greenwich was 24·3 inches. In Fig. 51, the percentage deviation of each year's rainfall is graphically displayed. The years of great epidemic prevalence are shown in black, of minor epidemic prevalence in columns enclosing small circles, while non-epidemic years are shown by the stippled columns. It is not always easy to distinguish between epidemic and inter-epidemic years; but the accuracy of the distinction can be tested in each instance by consulting the diagrams of yearly incidence of diphtheria.

It is plain that of the eleven years, 1855–64, in which diphtheria was more or less epidemic in England and in London, in only three, viz. 1859–60 and 1862, was the annual rainfall above the average line for 55 years. In the five years 1854–58, the rainfall was extremely light, and it was towards the end of these five years that the epidemic of diphtheria in London reached its maximum.

The diphtheria curve for London (p. 30) shows a distinct remission in 1860, corresponding to the increased rainfall of that year, rising again with the deficient rainfall of 1861 and 1863–64.

The deficient rainfall of 1873–74 was followed by a slight increase of diphtheria in 1874–75. In the thirteen years 1883 to 1895, the rainfall was above the mean line for 55 years, only on three occasions, viz. in 1888, in 1891, and in 1894. During this dry period an epidemic of unexampled magnitude prevailed in London.

It is evident from the above that there is in London no exception to the rule that *diphtheria only becomes epidemic in years in which the rainfall is deficient,* though in some years the excess of diphtheria in dry years is but small. There are no instances of a succession of wet years in which diphtheria was epidemic.

In London the number of deaths from croup were above the average from 1854 onwards (see Fig. 13, p. 30); and in view of this and other facts (see p. 51) it is probable that we must date the London epidemic from the year 1854, though its ravages did not become excessive, and it was not generally recognised before 1857–58. This failure to recognise the disease is in part explicable by the fact that scarlet fever was in the same years prevalent in a fatal form, and doubtless there was some commingling of the two diseases.

The above facts bring out more clearly the connection between the deficient rainfall of 1854–58 and the epidemic of the same years. In both the years, 1858 and 1859, in which the curve for England shows diphtheria at its absolute maximum, the river Thames ran so low in summer as to give out a stench,* "which was thought to forebode much fever."

* Quoted by Creighton from *British Medical Journal*, November 9th, 1861, p. 485.

The true significance of the relationship between rainfall and prevalence of diphtheria may be further elucidated by plotting out the yearly winter (October to March) and summer (April to September) rainfall. This is done in Fig. 52. It will be noticed that most commonly in dry

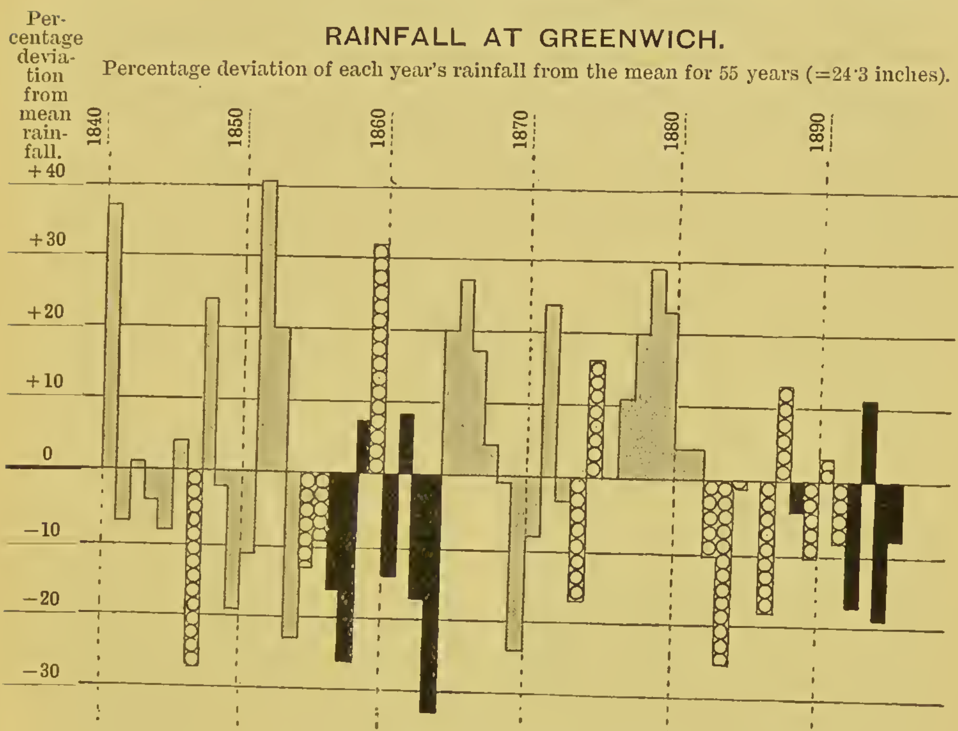


Fig. 51.

NOTE.—In this and the subsequent diagrams of rainfall, etc., the magnitude of the epidemic in any given year is not measured by the length of the black columns or of the columns enclosing circles in them. For the actual amount of diphtheria the diagram of yearly incidence of diphtheria for each place must be consulted. An attempt has been made, however, to distinguish between severe and less severe epidemics by using black columns for the former, and columns enclosing small circles for the latter, though the relative magnitude of these can only be ascertained by reference to the previous diagrams.

years the summer and the winter rainfall were both deficient in amount, though this is not uniformly so.

The BRIGHTON returns tell the same tale. The average rainfall in Brighton in the years 1868–96 was 29·3 inches. In 1874 diphtheria prevailed excessively, the rainfall in that and the foregoing year being below 25 inches. In 1884–85 diphtheria was excessive, with an annual rainfall

RAINFALL IN HERTFORDSHIRE.

Deviation of rainfall from the mean amount for the years 1842–92, in Hertfordshire, near London, for each summer (N.B. ⎍⎍⎍) and winter half-year (N.B. ⋀⋁⋀⋁), viz., from April to September, and from October to March respectively. The mean winter rainfall, 1842–43 to 1891–92, was 13·09 inches; the mean summer rainfall, 1843–91, was 13·24 inches.

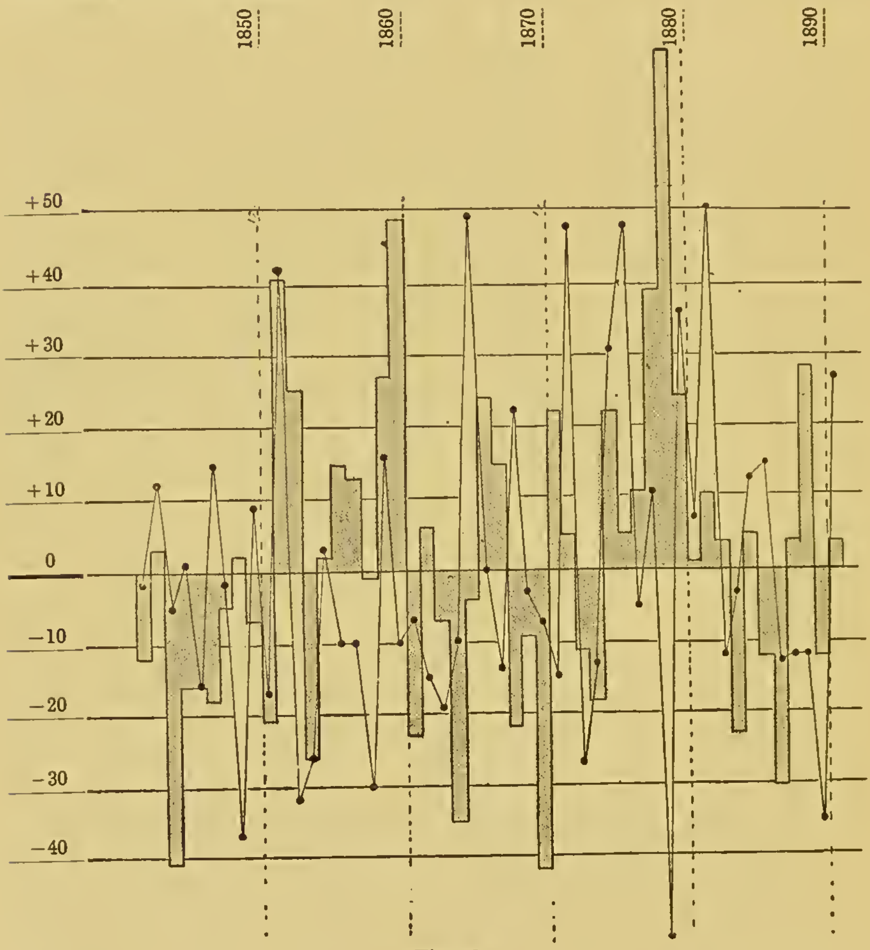


Fig. 52.

of 26 inches; in 1887–90 the rainfall was deficient every year (the average amount being under 26 inches), most so in 1890, when diphtheria was greatest. In 1893 there was again deficient rainfall with excessive diphtheria (see Fig. 14).

At CROYDON the average rainfall during 1867–94 was 26·3 inches. An epidemic maximum occurred in 1877 with a rainfall of 32·2 inches. This followed on four dry years, 1873–76, in which the rainfall was 25·7, 24·1, 26·9 and 26·8 inches respectively. It would appear, therefore, that in this, as in some other instances, dry seasons are provocative of diphtheria, especially when there is a series of them, and that the epidemic may continue and even reach its maximum in the wet year which follows the series of dry years (see Fig. 14).

In 1886 the rainfall in Croydon was 27·3 inches; in 1887 it was 22·7 inches, with an epidemic maximum. In 1890 the rainfall was 22·9 inches, with an epidemic peak. In 1892–93 there was excessive diphtheria with a rainfall of only 24·6 and 19·5 inches respectively.

Of the two Yorkshire towns, Sheffield and Bradford, the former shows some relationship between diphtheria and deficient rainfall; in the latter there has been so little diphtheria that the two cannot be compared.

For SHEFFIELD the mean annual rainfall during the twenty-two years, 1872–93, was 30·95 inches. During the first fifteen years of this period the rainfall was only below the average in two consecutive years, viz., 30 per cent. below in 1873 and 22 per cent. in 1874, without an appreciable rise in the death-rate from diphtheria. The next series of dry years was 1887 (40 per cent.) 1888 (15 per cent), 1889 (15 per cent.), and 1890 (17 per cent. below the average). In 1885 the rainfall was average in amount, and in 1884 it was +16 per cent. Fig. 18 shows that some epidemic prevalence of diphtheria commenced in 1885, gradually increasing until 1892, in which year the rainfall was −4 per cent., while in 1891 it was +6 per cent. The epidemic continued to a less extent in 1893, in which year the rainfall was +21 per cent.*

In BRADFORD the mean annual rainfall for the twenty-seven years, 1866–92, was 39·4 inches. In 1871, when the diphtheria record begins (Fig. 18), the rainfall was −24 per cent., being the fifth year in which it was below the average. From that year it was above the average each year except 1879 (−12 per cent.), 1884 (−6 per cent.), and 1885 (−7 per cent.). In 1887 and the consecutive years it was −33, −12, −20, −9 per cent., without any epidemic. What is the inhibitory condition of soil or climate causing Bradford and, to a less extent, other Yorkshire towns, to resist the development of epidemics of diphtheria under conditions which give rise to them elsewhere, I am unable to say.

The average annual rainfall at ABERDEEN for the twenty-nine years, 1866–94, was 30·7 inches. In 1870 the rainfall was −16, in 1871 it was −10, and in 1872 +43 per cent., with an epidemic peak in the last year. In 1878, with −9 per cent. rainfall, another epidemic peak occurred after three years of rainfall above the average. In 1884–86 diphtheria was excessive, with a rainfall of −13, −9, and −11 per cent.; but there was less diphtheria in the three next years, in which the rainfall was −14, −7, and −8 per cent. In 1893–95 excessive diphtheria followed a rainfall in 1890–94 of +6, −7, −2, −3, and −6 per cent. respectively.

At GLASGOW the average annual rainfall was 39·45 for the twenty-seven years, 1865–93 (omitting 1884 and 1887,

* Since the above was written, I have ascertained the annual rainfall in Sheffield (Broomhall Park) from 1866–71. In all these years it was at or above the average for the years 1872–93, except in 1870, when it was 26·01 inches; and during the same period diphtheria mortality was on the decline.

for which years the records are defective). From 1866 the rainfall was excessive until 1869–71, when it was average in amount, −10, and +4 per cent. respectively. From 1881 onwards it was below the mean line in every year for which records exist, but there are no great epidemic peaks, though evidence of excessive prevalence appears in 1882, in 1886–88, and in 1895. Diphtheria varies comparatively little in amount from year to year in Glasgow, being constantly endemic on a fairly large scale, and climatic conditions appear to play a minor part in its production and continued prevalence.

The comparison of Edinburgh with Glasgow is interesting. The former in the fifteen years, 1866–80, had a mean annual rainfall of 28·32, the latter in the same period of 43·08 inches. During these years Edinburgh had an epidemic peak in 1871, which was the third year in succession of sub-normal rainfall. Glasgow had three years of normal and sub-normal rainfall, 1869–71, and a small peak was reached in 1872. The epidemics of diphtheria are of much greater magnitude in Edinburgh than in Glasgow, but the amount endemically present is greater in the latter than in the former city.

In Christiania the relationship between deficient rainfall and excessive diphtheria is very evident.

In 1869–70–71 the rainfall was low, and the records show very little excess of diphtheria. In 1875–76 the rainfall was again deficient, without excess of diphtheria. From 1884–1889 inclusive the yearly rainfall was low, and coincident with this, Christiania had the greatest epidemic of diphtheria from which it has ever suffered. On the other hand, the epidemic maximum in 1862 coincided with a year of rather heavy rainfall, following on two previous years of excessive rainfall; while there is no statistical record for the years 1851–59, in which the rainfall was almost uniformly below the average, and in most years greatly so. When this volume was preparing for press, it was necessary to send Fig. 53 to be executed, although it apparently embodied an important exception to the rule previously stated, of coincidence between

RAINFALL AT CHRISTIANIA.

Percentage deviation of each year's rainfall from the mean for the 45 years, 1851–95 (=23·8 inches).

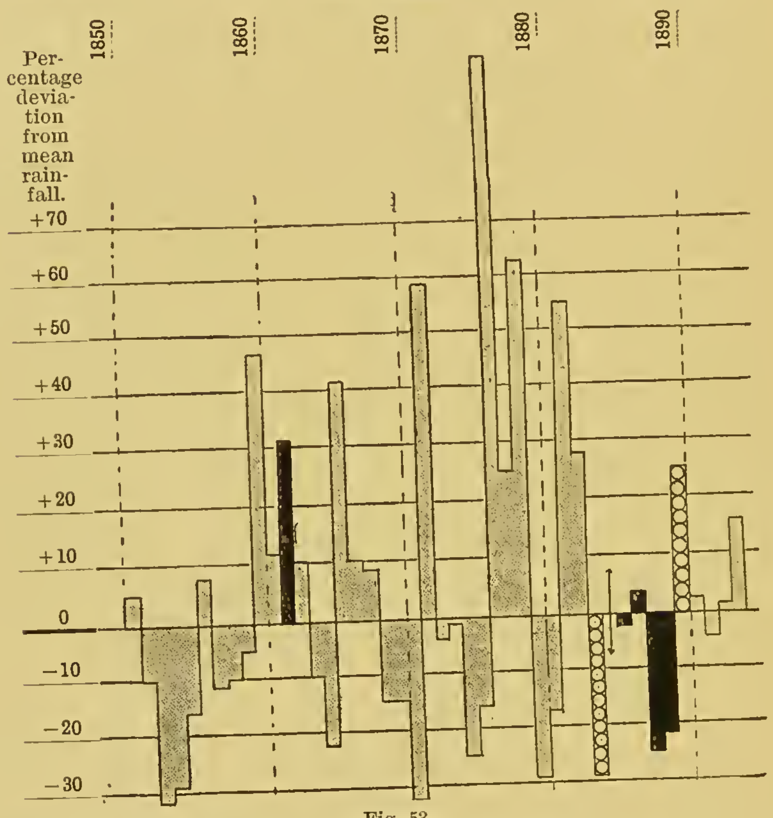


Fig. 53.

NOTE.—The years 1857–65 ought all to appear as black columns (see evidence on pages 122–6).

epidemic diphtheria and dry seasons. But while writing (Dec. 24th), a letter from Dr. Bentzen, the Medical Officer of Health of Christiania, has entirely cleared up the apparent discrepancy. The exact details furnished by him are stated on pages 122–6. From these it is clear that diphtheria was already slightly prevalent, 1851–54, and that in 1857–58 it became widely prevalent, due allowance being made for the fact that it was only imperfectly recognised as such. In 1859 the number of cases was higher than in any of the subsequent years shown in the table on page 126, with the exception of 1862–64. There was a slight lull in 1861, a second year of excessive rain-fall; but the epidemic increased in the next wet year and persisted to the end of the next dry period in 1865. The persistence of the epidemic during the comparatively wet years, 1860–64, represents the continuance of the evil produced in the preceding dry years. *The epidemic owed its genesis to* the conditions prevailing in *the long series of dry years*, 1852–59, and all the great epidemics, of which we have exact knowledge, appear to have a similar genesis.*

In Germany the same relationship between epidemic diphtheria and deficient rainfall is visible.

For Hamburg I have only returns of rainfall from 1877–1895, the average annual rainfall for which period was 726·6 millimetres. In 1877–80 the rainfall was much above the average with a relatively small amount of diphtheria. For the next three years the rainfall was small, while in 1884 it was slightly over the average. During these years the amount of diphtheria was increasing. In 1885–6–7 the rainfall was exceptionally small, and diphtheria reached its absolute maximum. In 1888–91, with excessive rainfall, diphtheria fell to its

* Hirsch (*Syd. Soc. Trans.*, vol. iii. p. 86), says, "Diphtheria began to epidemic in Norway about the same time, first in 1845 in Trondhjem, the year after at Thoten, 1847 at Levanger and Skogn, after that in the district of Namdal, *while the general diffusion over the country took place in the year* 1855 (*Cold. Ugeskrift for Laeger*, 1867, Nr. 28).

minimum, rising to a fresh peak in the second of the two dry years, 1892–93.

In BERLIN the same relationship is visible, though, as in Hamburg to a less extent, the large total amount of diphtheria endemically present makes it difficult to establish it satisfactorily. The years 1875, 1882, 1884, and 1893 were dry years and years of epidemic maxima.

At FRANKFORT-ON-THE-MAINE I have only been able to find a record of rainfall from 1855–63. This, however, is interesting as showing that the 1857–8 epidemic peak (Fig. 33) occurred in years in which the rainfall was only 16·65 and 18·43 Parisian lines respectively, after a rainfall of 25·06 in 1855 and of 32·36 in 1856. In 1863 the rainfall was 19·64 lines, after three years in which it had been 30·15, 25·59 and 26·50 respectively. This was followed by a large epidemic peak in 1864–5. I have no rainfall records for these latter years.

Among American records the same difficulty arises as in the curves for European towns. The amount of endemic diphtheria is so great that it is only by considering the apices of the diagrams that the influence of wet or dry seasons can be judged.

The NEW YORK diagram (embracing the twenty-eight years, 1868–95, with an average annual rainfall of 44·0 inches) shows deficient rainfall in the three years 1875–77, accompanied by a great epidemic in these and in the next following year, in which the rainfall was above the average. In the second of the next three dry years, 1879–81, excess of diphtheria showed itself, reaching its maximum in the third dry year, and continuing to a less extent into the following year, in which the rainfall was a little above the average. A similar experience is repeated with almost mechanical uniformity in connection with the two next epidemic peaks. After two years of excessive rainfall, the rainfall was below the average in 1884–85, at the average in 1886, while diphtheria increased from its minimum in 1883 to a great epidemic culminating in 1886–88, and therefore continuing

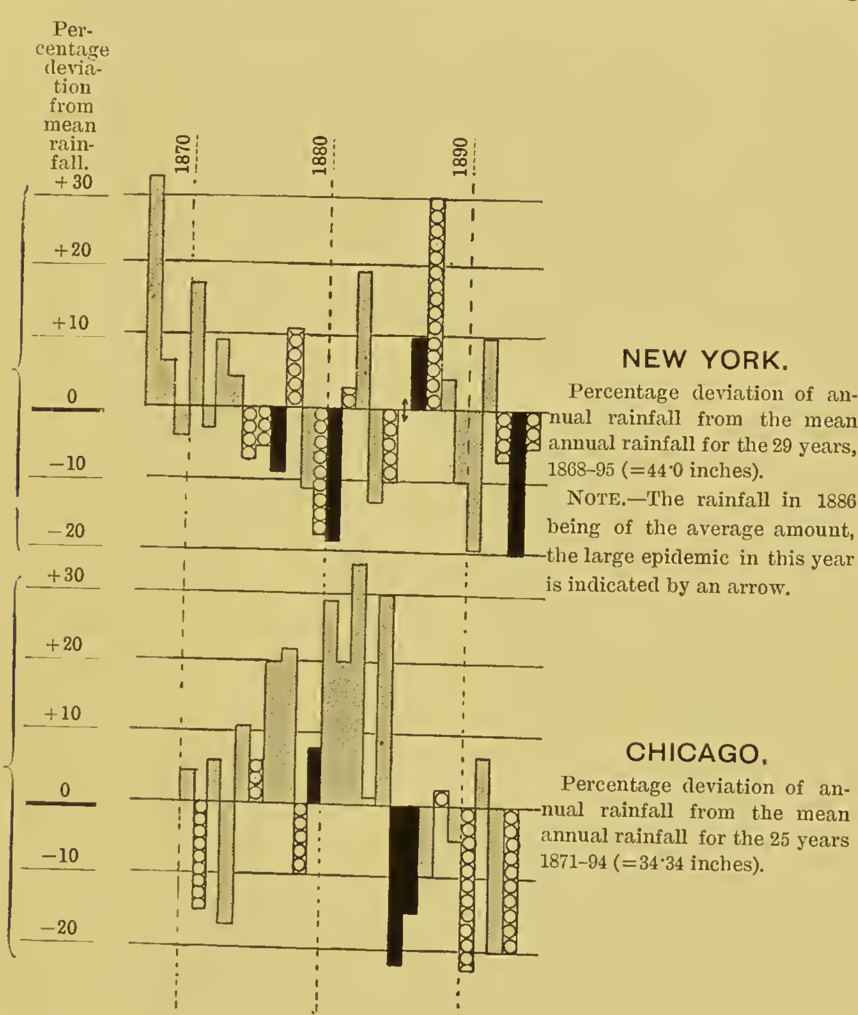


Fig. 54.

into the comparatively wet years 1887–89. In 1893–95 very dry years were associated with a large epidemic of diphtheria.

The rapid recurrence of the epidemics in New York lends itself to the supposition that the climatic factor is here at least of greater importance than the accumulation of susceptible children. It is doubtful if a previous attack confers the slightest permanent immunity from a second attack of diphtheria, and whether the com-

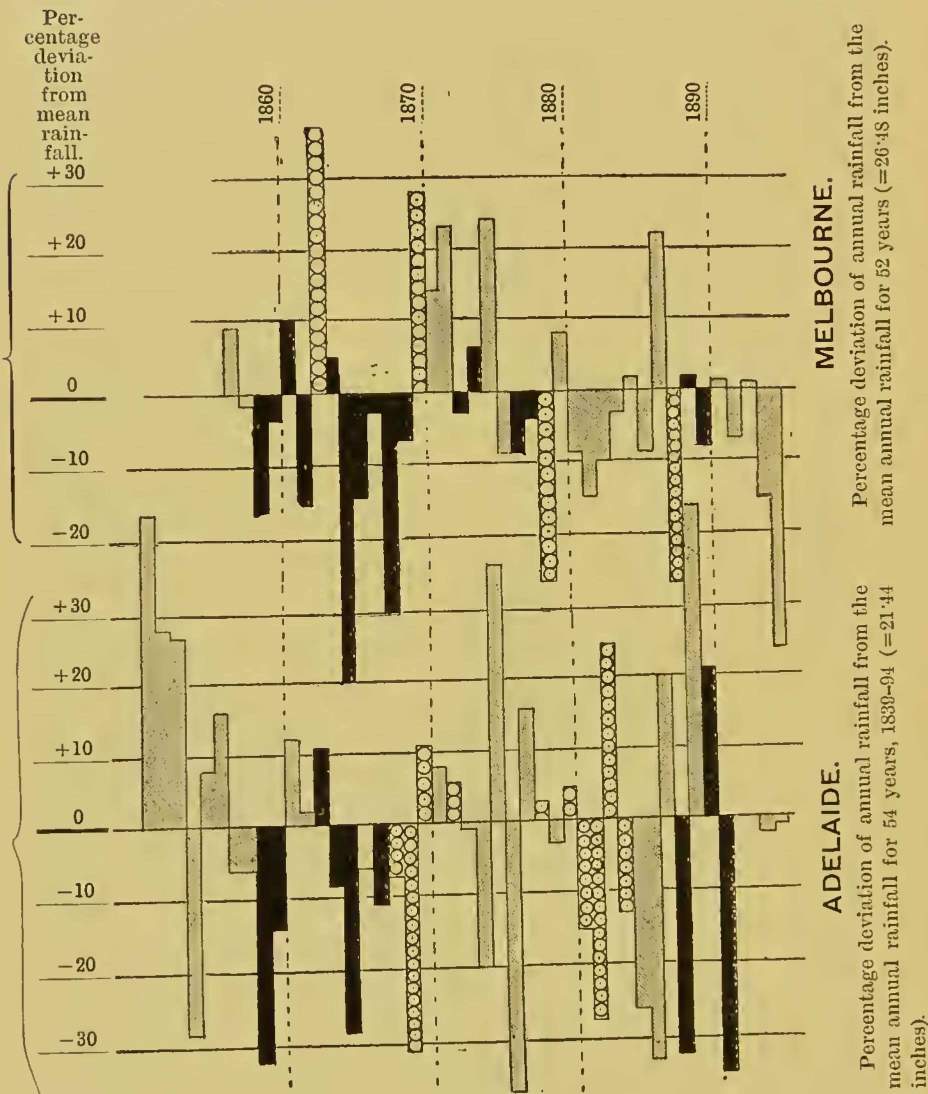


Fig. 55.

parative rareness of second attacks in the same person is not due to the diminished liability to attack associated with advancing age.

The record of rainfall in CHICAGO embraces the twenty-five years, 1871–94, during which it averaged 34·34 inches. The epidemic peaks are relatively smaller, while the amount of diphtheria constantly endemic is greater than in New York. So far as the influence of rainfall is evident, there was an epidemic peak in 1876 unassociated with, and not immediately preceded by, a year of deficient rainfall. With this exception the usual association between epidemic peaks and deficient rainfall is seen.

The Australian returns also show the relationship between deficient rainfall and excessive diphtheria. Thus, if the diagrams of diphtheria in Melbourne and Adelaide (Fig. 42) be combined with those for the colonies of Victoria and South Australia (Figs. 41 and 43), of which they are the capital towns, the result is as shown on the accompanying diagram of rainfall (Fig. 55). The great epidemics are plainly associated with years of deficient rainfall. The only apparent instances of an epidemic beginning in years of rainfall above the average are in Adelaide in 1863 (judging by the diagram for the whole of South Australia, the diagram for Adelaide only dating from the year 1875); in 1872, where the same remark applies; and in 1890. In the first two of these instances we almost certainly have to deal with epidemics owing their genesis to previous years of protracted deficiency of rainfall, and continuing into the comparatively wet years.

It is not without significance that of the three chief Australian towns, Sydney, with an average annual rainfall (for 1840–95) of 49·72 inches, has, as may be seen by a glance at Fig. 42, least diphtheria; Melbourne, with an average rainfall (for 1857–95) of 26·48 inches, considerably more diphtheria; and Adelaide, with an average rainfall (for 1839–94) of 21·44 inches, has the largest amount of diphtheria, if we compare the period 1875–95 common to the three diagrams (Fig. 42). Dr. Borthwick, of Adelaide, has supplied me with a valuable table of rainfall of Adelaide, with remarks upon it. From these remarks I make the following extracts as to the three exceptional years named above:—" 1863, wet October" (rainfall only 11 per cent. above mean). "1872, good rains in May, June, July" (rainfall only 6 per cent. above mean). "1890, dry summer, followed by wet winter, wet October to November, very dry December" (rainfall 21 per cent. above mean).

The New Zealand diagram (Fig. 44) shows much less diphtheria than that of any part of Australia. In judging of the relationship between diphtheria and rainfall in New Zealand one has to remember that the diphtheria statistics do not deal with single towns, but with sparsely populated and extensive districts. Allowance being made for this, the epidemics of diphtheria show a close relationship with years of deficient rainfall. The records of rainfall for 1878 are missing.

Fig. 56 compares the deviations of rainfall from the mean amount in Auckland in the Auckland district, North Island, and the epidemics of diphtheria, with the same data for Christchurch (1867–80) and Lincoln (1881–95), towns within a few miles of each other in the district of Canterbury, South Island. There is no complete record for a single town in Canterbury for the entire period. In Auckland (Fig. 45) the epidemic peaks are but small, but the chief one began in 1873–74, which were average or dry years, and extended into the two subsequent wet years. If we take the croup part of the diagram, a smaller epidemic, 1884–85 corresponded to these two dry years, and in 1891 occurred another very slight peak with deficient rainfall.

Canterbury shows much more diphtheria than any other district of New Zealand. In the dry years, 1872–74, a great epidemic occurred in years two out of three of

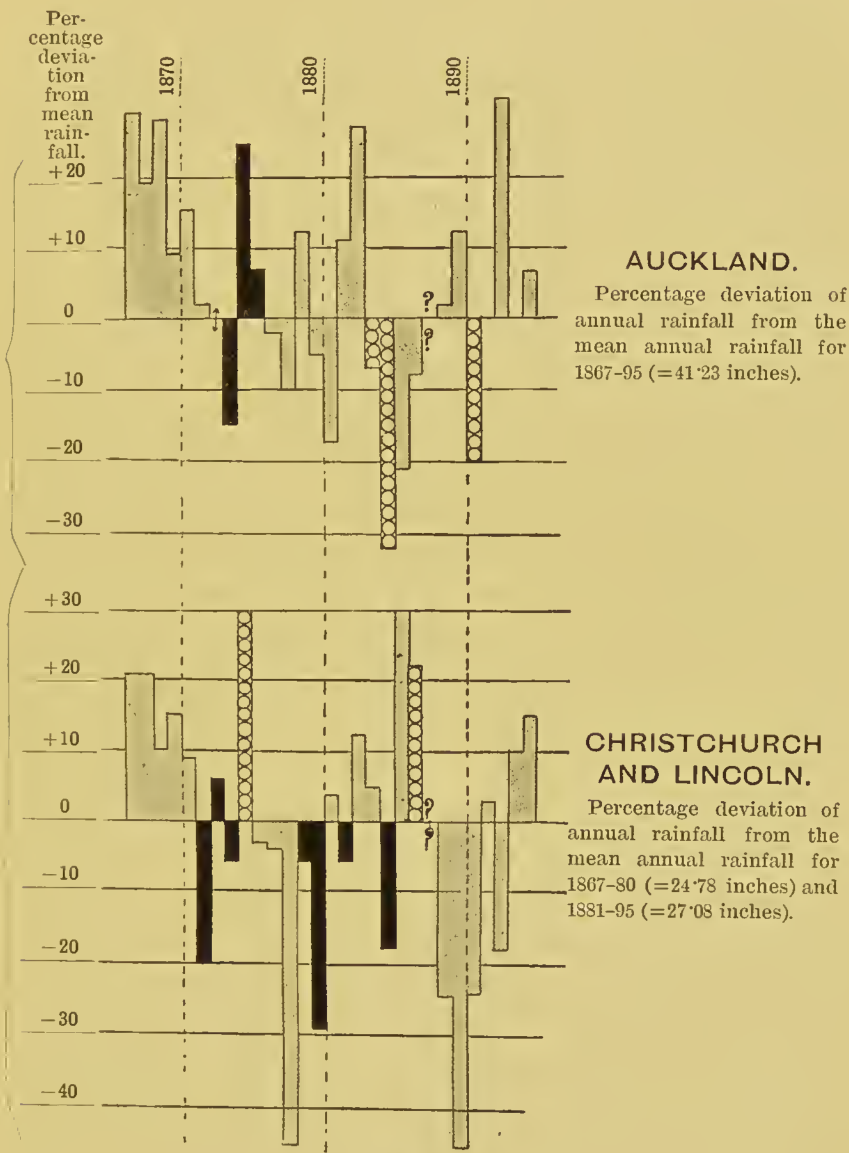


Fig. 56.

which were dry, the epidemic being mitigated in the next wet year. A further peak was reached in 1879–80, two dry years, following upon four preceding dry years. The year 1887 appears to be an exception to the general rule, and no epidemic followed the three dry years, 1889–91.

Mr. Leslie, in sending the valuable figures for New Zealand, which I have used somewhat copiously (Figs. 45–47) remarks: "Why the Canterbury district has so relatively high a death-rate from diphtheria I am quite at a loss to explain." He adds: "The chief characteristic of the district is that it is less hilly and broken up than the other provincial districts, the Canterbury plains being far famed for grass, mutton, and wheat. All along the east coast * the land is flat, with the exception of Banks Peninsula, and the land rises gradually to the west till the line of the Southern Alps is reached, which forms the western boundary of the district. It is well watered, all the rivers of any consequence taking their rise in the snow-clad Alps, the chief of which is Mt. Cook; but I like to think of it under its Maori name, Aorangi, or rather Anoa-rangi, "the pioneer of the clouds of heaven." In many places, especially about the city of Christchurch, Artesian wells are so numerous that I am not aware of any other domestic water-supply for the inhabitants." If we add to the above, what might be anticipated from Mr. Leslie's graphic description, that the mean rainfall at Christchurch in Canterbury for the years 1867–80 was 24·78 inches, at Lincoln, a neighbouring town, for the years 1881–95 was 27·08 inches, while the average at Auckland for the years 1867–95 was 41·23 inches; at Wellington, 39·82 inches; and at Dunedin, 36·86 inches; we are prepared to associate the relative excess of diphtheria in Canterbury with its relatively deficient rainfall.

* The map of New Zealand should be consulted.

CHAPTER XVII.

THE RELATIONSHIP BETWEEN RAINFALL AND DIPHTHERIA

THE towns and districts in which the coincidence of excessive annual rainfall and scanty diphtheria, and of scanty rainfall and excessive diphtheria, occurs might be multiplied; but those given in the preceding chapter will suffice to bring out a completely unexpected conclusion.

I anticipated results which would agree with the generally accepted belief in the etiological connection between damp houses and damp soil and the origin of diphtheria. Although Oertel * says "the disease is not affected by either heat or cold, drought or rain," the majority of observers have assumed and believed that wet weather favours the origin and spread of diphtheria. There has, so far as I know, been no attempt to distinguish between the effects of wet weather occurring in years which have an average rainfall or are excessively wet throughout, and wet weather occurring during or following upon periods of protracted deficiency of rainfall, as I shall endeavour hereafter to do. It was therefore a great surprise to me to find that the great pandemics of diphtheria, so far as my information extended, had all occurred during periods of exceptional drought.

The following general induction is, I think, warranted by the instances already adduced :—

Diphtheria only becomes epidemic in years in which the rainfall is deficient, and *the epidemics are on the*

* Vol. i. p. 583 of Von Ziemssen's *Cyclopædia of Medicine* (English translation, 1875).

largest scale when three or more years of deficient rainfall immediately follow each other. Occasionally dry years are unassociated with epidemic diphtheria, though usually in these instances there is evidence of some rise in the curve of diphtheritic death-rate. Conversely, diphtheria is nearly always at a very low ebb during years of excessive rainfall, and is only epidemic during such years when the disease in the immediately preceding dry years has obtained a firm hold of the community, and continues to spread presumably by personal infection.

Apart from the exact records of rainfall and of incidence of diphtheria, upon a comparison of which the preceding general proposition has been based, certain general considerations strongly confirm the same induction.

The records for India show that diphtheria is a comparatively *rare disease in tropical climates,* the main characteristics of which are not only excessive heat, but also excessive humidity of air and excessive rainfall.

Furthermore, the fact that diphtheria may be described as *relatively a continental rather than an insular disease* is in favour of the induction. The curves given in Figs. 1–47 show that diphtheria is immensely more rife in the great cities of the European and American continents than in British and Irish towns, and than in the different districts of New Zealand.

The essential difference between continental and insular climates consists in the greater variations in temperature and in rainfall characterising the former; and the rainfall may be taken as the index of these variations. Dr. F. Waldo remarks*: "In fact, there is found to be the general law that the intensity of the oscillations of rain-

* *Modern Meteorology* (Walter Scott, 1893), p. 409.

fall increases with the continentality of the region." The following table is extracted from Dr. Waldo's work (p. 409). It expresses the average maximum and minimum rainfall and the ratio between these two according to the continental distribution, based on the experience of the years 1830–80.

	Rainfall in Millimetres.		
	Average Min.	Average Max.	Ratio of Max. to Min.
Eastern part of England	599	744	1·18
North Germany	573	705	1·23
South West Russia	447	570	1·26
South East Russia	273	384	1·40
U. S. America, West Coast	379	517	1·38
" far Western interior .	483	684	1·42
" Eastern interior . .	890	1059	1·20

Thus for every 142 mm. rainfall occurring in the wet periods there are 100 mm. in the dry periods in Western America, while in England the difference is only as 118 : 100.

The *increased oscillation in amount* of rainfall is not the only difference in respect of rainfall between insular and continental climates. There is a *difference in the actual amount,* whether we take extremes or averages. Thus the average minimum and maximum rainfall is much higher in England, with its comparatively trifling amount of diphtheria, than in most of the continental regions, in which diphtheria is so fatally endemic and epidemic.

The induction is further favoured by the fact that where such comparison is practicable, *in a given country the amount of diphtheria is greatest in the parts having the smallest rainfall.*

Compare on this point Bristol with London, or Bradford, Huddersfield, or Halifax with Sussex or Norfolk. Speaking generally, in this country towns on the west coast have much less diphtheria than those inland or to the east of the ranges of hills which determine the rainfall in inland towns. The small amount of diphtheria in rainy Ireland confirms the same result; and although Glasgow appears to be a partial exception to this rule, when contrasted with Edinburgh, it is so solely because diphtheria in Glasgow is chiefly an endemic as contra-distinguished from an epidemic disease.

The comparison between Australia and New Zealand brings out the same point. The climate of Australia is continental in character, long periods of drought interrupted by rainfall of tropical or sub-tropical amount being common. The case of New Zealand is of special interest, as may be gathered from the number of diagrams which have been constructed for it (Figs. 44 to 47).

The contrast between the district of Canterbury and the other districts of New Zealand has been sufficiently emphasized on page 156. So also has the contrast between Melbourne, Sydney, and Adelaide (p. 153). Denver, in Colorado, is an instance of an extremely dry place, with excessive diphtheria.

It may be asked why the consideration of the relationship between deficient rainfall and epidemic diphtheria has been confined almost entirely to urban communities. There are good reasons for this. It is almost impossible to obtain statistics of diphtheria for rural districts, stretching over a sufficiently long range of years. Even if they could be obtained, the curve constructed from them would be subject to the violent accidental oscillations necessarily associated with statistics based on sparse numbers. If wider areas, as counties, were taken, another source of fallacy would be introduced. In a slowly spreading disease like diphtheria, largely spread by personal infection, the different districts of a country are not, as a rule, simultaneously affected, and the mortality curve constructed on the basis of the combined experience of these districts would be smoothed out, and not represent the actual experience of any particular district.

This objection holds in great towns to a much smaller extent. Hence the experience of towns has been selected deliberately, as furnishing more exact data, on a sufficiently large scale to avoid accidental causes of variation, and enabling the fundamental causes of pandemics to be examined under favourable conditions.

If the coincidence between periods of deficient rainfall and epidemics of diphtheria be a constant one, there can be no hesitation in regarding the relationship as causative in character. To test this conclusion, we must inquire as to the occurrence of

(1) Periods of exceptional deficiency of rain without the occurrence of epidemics of diphtheria; and of

(2) Wet periods in which such epidemics began.

In 1873–74 there was deficient rainfall in London, with only a slight excess of diphtheria. But, as already pointed out, this was a much less protracted deficiency of rain than that characterising the great epidemics of 1857 onwards and 1887 onwards. The same remark applies in a less degree to the 1873–76 deficiency of rainfall at Christiania, and to similar occurrences elsewhere.

Instances may be quoted, as at Bradford and probably Leicester and other towns, in which there has been a succession of comparatively dry seasons without epidemics of diphtheria, notwithstanding that a small amount of diphtheria is endemic in these towns, ready, presumably, to produce a destructive epidemic when the conditions necessary for this arise. I am unable to explain what are the local influences in these instances which protect them from epidemic diphtheria, or whether, in fact, their comparative immunity to the present time is not due to accidental causes.

Wet periods associated with epidemic diphtheria present greater difficulties than dry periods in which it does not appear. The chief instances of epidemic peaks associated with excessive rainfall are in Chicago in 1876, Adelaide in 1863 (doubtful, see p. 153), and in 1872 and 1890, and Canterbury, New Zealand, in 1887. Assuming the accuracy of the data respecting these exceptional years, it will be noted that the epidemics occurring in them were not of the exceptional magnitude characterising epidemics associated with a series of dry years. It must be remembered also that it is not claimed for dry seasons that they are the sole and sufficing cause of diphtheria. The essential *causa causans* of diphtheria is the invasion of susceptible persons by the Klebs-Lœffler bacillus. This does not, however, exhaust the causation of diphtheria. If we find this bacillus in a house or town, an epidemic of diphtheria therein is not sufficiently explained. The bacillus may constantly be found in the throats of sporadic cases of diphtheria during inter-epidemic periods, and yet no epidemic arises in these intervals, which are sometimes protracted over long years. It may also be found in the throats of attendants upon diphtheritic patients, without any illness on their part. To exhaust the etiology of an infectious disease like diphtheria, we require,—adopting the phraseology of the old scholastic logicians,—to know not only the *causa causans* of the disease (that is, the specific micro-organism) but also the *causa efficiens* and the *causa movens*, which must be present in order that the disease may become widely prevalent. To use a simple illustration. A drunken man is thrown by a restive horse, and dies from a broken and dislocated neck. The cause of death may with accuracy be ascribed to the man's drunkenness, to the restiveness of the horse, or to the fractured and dislocated cervical vertebra. Properly it is ascribed to the conjunction of all these circumstances. A neglect to consider any one of these factors will give a distorted and imperfect view of the cause of the accident and its fatal issue. So it is with infectious diseases, and especially with diphtheria, in which the influence of personal predisposition and of environment is so marked. The bacteriological study of diphtheria, far from being the negation of traditional etiology, is but the logical outcome of it; and secondary causes still maintain their traditional value as the indispensable concomitants of the Klebs-Lœffler bacillus. The *causa efficiens* and the *causa movens* consist of the combined favouring influence of personal constitution and conditions of environment, which Colin has named "le milieu épidémique." * Mr. Justice Fry says: "There is, so far as I know, no physical or logical distinction between principal and minor causes or between cause and conditions in the case of two or more constituent parts of a cause, each of which is necessary, and none of which is by itself sufficient." †

We have seen that nurses and others may receive the *causa causans* upon the mucous membrane of their throats, without suffering from the attack of diphtheria which would follow in susceptible subjects. It need not therefore be the subject of surprise that occasionally when the external conditions are those known to be favourable to the development of diphtheria, an epidemic does not occur. The occurrence on the rare occasions noted above

* Article on Epidémie: *Dictionnaire Encyclopédique des Sciences Médicales.*

† *Nature*, Nov. 1st, 1894.

of epidemics when these external conditions are known to be unfavourable, is also explicable on similar grounds. In the illustration previously given, the man might have broken his neck, even if he had not been drunk, or if his horse had not been restive. And yet, in the instance given, these were essential contributory causes of the accident. That they were so is indicated also by the frequency of this particular accident when they are present and its rarity in their absence. Similarly with diphtheria. An occasional outbreak may be caused by personal infection in an overcrowded elementary day school or in a densely populated and insanitary district, where the circumstances favour the acquirement of the property of increased infectivity, even though it be in the midst of wet seasons; but such instances are very rare. This does not controvert or disprove the statement here advanced that the chief efficient and motive cause of epidemics, and still more of pandemics, of diphtheria is the occurrence of a series of dry years, giving rise to conditions which favour the multiplication and probably at the same time increase the virulence of the diphtheria-bacillus.

In advancing this statement, I am aware that the experience on which it is based is somewhat limited. It is, however, as extensive as available data, collected with incalculable trouble, can make it. It is of the essential nature of a cause that one, being aware of its existence, should be able to predict the corresponding result, or conversely be able to state that this result will cease to appear when the cause is removed. The difficulty of doing this in respect of diphtheria is the occasional occurrence of minor epidemics in the absence of the favouring climatic conditions. But *these are not great* *epidemics or pandemics.** We may, notwithstanding these, apply the preceding test to epidemic diphtheria, and prophesy that almost certainly the present great epidemic of diphtheria in London will subside, and diphtheria decline towards its "normal" endemic amount, when we have completed the present cycle of dry years, and pass into a wet period. A remarkable instance of a similar investigation with a similar forecast is given by Dr. Waldo,† quoting from an elaborate research by Professor Brückner of Berne. Brückner has made use of observations of rainfall at 321 points on the earth's surface, distributed as follows: Africa, 6; Australia, 12; Central and South America, 16; North America, 50; Asia, 39; Europe, 198. For most of the stations the data are for the years 1830–85. For the averages five-yearly periods are taken. The results are classified in the following table (see p. 166).

* The only instance of a very severe epidemic of diphtheria occurring in comparatively wet years which I have been able to discover was in 1881–82 in Portsmouth. I have no record of the rainfall before 1880, but in the epidemic years, 1881–82, the annual rainfall was 32·0 and 29·0 inches respectively, while in the immediately succeeding years, 1882–85, after the epidemic had disappeared, it was 29·3, 27·6, 21·6, and 27·5 inches respectively. The annual reports of the medical officer of health leave little doubt that school infection was extensively at work, the defective condition of the main sewerage and house drainage, and the unsatisfactory character of the soil on which a large number of new houses had been built, being also adduced as co-operating causative influences. Dr. Sykes' annual report for 1881 contains the following remarks: "To the congregating of large numbers of children in schools I attribute the wide spread of this epidemic beyond all other epidemics of the same disease. . . . A marked diminution of those attacked was shown at the close of the summer holidays."

† *Op. cit.*, p. 407 *et seq.*

	Periods of Rainfall.				
	Deficiency.	Excess.	Deficiency.	Excess.	Deficiency.
Europe	1831–40	1841–55	1856–70	1871–85	—
Asia	1831–40	1841–55	1856–70	1871–85	—
Australia	–45	1846–55	1856–65	1866–75	—
North America . .	1831–40	1841–55	1856–65 (71–75)	1866–70 (76–85)	1876–85
Central and South America. . . .	1831–45	1846–60	1861–75	1876–85	—
Taken all together	1831–40	1846–55	1861–65	1876–85	—

Dr. Waldo, after summarising the facts as to rainfall in the table, adds, "It would appear probable that we are now entering upon another period of very low rainfall during 1890–95."* This forecast has proved correct, the dry period being still (January, 1898) with us in England.

It is impossible exactly to compare such average results with the diphtheria diagrams for particular towns in different countries, which have not been constructed by a similar system of averaging. But with this proviso the preceding table is most suggestive. The period of deficiency of rain, 1856–70, evidently coincided in Europe Australia and North America with a period of pandemic diphtheria. No records of diphtheria exist for the corresponding period in Central and South America and in Asia, but we know that diphtheria does not thrive in the tropical parts of Asia.

The next period of excess of rainfall was one characterised by local epidemics; but a rapid survey of all the diphtheria diagrams indicates that there was on the whole a lull in the prevalence of diphtheria during this period.

* *Op. cit.*, p. 411.

At the time when Brückner constructed his diagram the next period of deficient rainfall had only arrived in North America (1876–85), and a glance at the American diagrams shows that this was the period *par excellence* in which diphtheria was fatally prevalent in the States. Since then Europe has had its dry period. It still persists in England, and with it an epidemic of diphtheria, which is only equalled by that of 1856–65.

CHAPTER XVIII.

THE INFLUENCE OF SOIL UPON THE DEVELOPMENT OF DIPHTHERIA.

It has become established almost as an axiom in medical writings that there is a close etiological connection between damp houses and the origin of diphtheria. Many years ago Dr. Thursfield showed (*Lancet*, August, 1878) that diphtheria hung about damp houses. This observation has been confirmed by others, and it may be that we have in it a partial explanation of the reason for the excessive endemicity of diphtheria in North Wales, where houses are so commonly found built against hillsides, without damp-proof courses, and often without through ventilation. The fact that epidemic diphtheria arises chiefly in exceptionally dry years does not necessarily invalidate this observation. Damp houses mean cold, a great vital depressant, favouring sore throat and catarrh, and thus preparing the way for the inroads of the diphtheria-bacillus.

This remark naturally leads to a statement of the distinction which I regard as most important, between rain occurring during a dry year and rain forming part of a wet year. The latter gives the diphtheria-bacillus an effectual quietus, especially when the excessive rainfall is continued in a second or third consecutive year; the former produces outbreaks of the disease due in all probability to the diphtheria-bacillus being driven from its normal habitat in the soil, and obliged to take refuge, if we may use the language of volition, in a parasitic life.

I have plotted out the dates of onset during the last two years of all notified cases of diphtheria and other notifiable diseases in my own district, on a chart giving the daily variations of the chief meteorological data. The association has been so regular that I am now in the habit of anticipating that whenever a rapid fall in the barometer occurs, especially if this is associated with rainfall, a sudden increase in the notifications of infectious diseases, especially of diphtheria and scarlet fever, will occur, due allowance being made for periods of incubation.* Similar observations, with a similar result, have been made in respect of rheumatic fever, although, owing to the fact that this disease is not compulsorily notifiable, the data are on a scanty basis.

Hence the association between wet weather and limited outbreaks of diphtheria, so frequently observed, is one which I can quite confirm. This remark, however, applies only to the sporadic cases which cannot be traced to any source of personal infection. The outbreaks due to personal infection at school or elsewhere or to infected milk, occur equally in dry or wet weather.

We may next pass on to the influence of soil. The present consensus of opinion favours the view that a damp cold soil is most favourable to the production of diphtheria. The following extracts will make this clear.

Dr. Copeman † says: "Many districts, which, although usually dry, are liable to occasional floods, are remarkably free from the disease, so that it appears that a persistent impregnation of the soil with moisture is of more import-

* Dr. M. A. Adams, the Medical Officer of Health of Maidstone, drew attention to this association in his annual report for 1889.

† Article on "The Influence of Soil on Health" in Stevenson and Murphy's *Treatise on Hygiene and Public Health*, vol. i. p. 339, 1892.

ance than fluctuations in the height of the ground water, particularly if these have any considerable range." These remarks appear to imply an antithesis between dry soils and diphtheria, as well as a causative relationship between persistently moist soils and diphtheria, on both of which issues I must give an exactly opposite opinion.

Dr. (now Sir Richard) Thorne Thorne, while agreeing that "the broad geological features of a district have no known influence on the development or the diffusion of diphtheria," states that he can hardly agree with Hirsch that "the assumption that *conditions of soil* have some influence in the development of diphtheria, or on its epidemic diffusion, is one that has no warrant." The essence of Dr. Thorne Thorne's teaching is contained in the following paragraph: "Soil, and especially *surface soil*, when considered in connection with relative altitude, slope, aspect, and prevailing rainfall, has, I believe, concern in the maintenance and diffusion of diphtheria, and has very possibly some relation with its beginnings. Speaking generally, I think that the experience of careful investigations extending over a number of years is to the effect that where a surface soil is, by reason of its physical constitution and topographical relations, such as to facilitate the retention of moisture and of organic refuse; and where a site of this character is, in addition, exposed to the influence of cold wet winds, there you have conditions which do tend to the fostering and fatality of diphtheria, and which also go to determine the specific quality of local sore throat." *

Dr. C. Kelly, Medical Officer of Health of the Combined District of West Sussex, covering an area of about 524 square miles, with a population in 1889 of 105,520, has shown that when the diphtheria statistics of a series of

* *Natural History of Diphtheria*, p. 17 *et seq.*

years are combined, the death-rate per million among the population living on pervious soils (as green-sands and chalk) is 127; among those living on moderately pervious soils (chalk covered with loam and brick-earth), 216; among those living on retentive soils (weald clay and other clayey beds), 454.* The method employed in this and all similar investigations into the geographical distribution of epidemic diseases appears to me to be fundamentally open to objection, though it is, I admit, difficult to suggest a substitute entirely free from objection. The diagrammatic method employed in the preceding pages, giving pictorially the death-rate for each single year of a long series, enables one to see almost at a glance the relative amount of diphtheria in large communities, concerning which a comparison is desired. It would, however, give violent accidental oscillations if applied to rural districts with sparse populations. If this method were applied to the varying districts in West Sussex, it would, I have no doubt, be found that the annual death-rate from diphtheria among populations on either pervious or impervious soils was high in dry years, especially if more than two consecutive dry years occur, and low in wet years. It is difficult to say how much of the excess of diphtheria in populations on pervious soils would remain after correction for age distribution. I do not suggest that this factor explains more than a portion of the difference. It appears to me that the materials are not yet available for an exact comparison of the *quantity* of diphtheria in different districts, except on a scale sufficiently great to eliminate accidental variations due to relative facility for the introduction of infection, and so on; as when one compares an English with a German or an American city. It is only possible at present accu-

* See *Elements of Vital Statistics*, p. 121.

rately to compare each district with itself, determining the periods of maximum and minimum prevalence of diphtheria—comparing district with district, or city with city, rather from the point of view of times of incidence of the maxima and minima, than with a desire to weigh or measure the actual amount of the disease. This point leads to a consideration of Dr. Longstaff's investigations, based on the decennial death-rates caused by diphtheria in the different counties of England. His statistics have been continued up to the end of 1895 by Dr. W. R. Smith, the Medical Officer to the London School Board, and the maps accompanying the latter's report furnish a ready means of comparison of each county from 1861 to 1895. But decennial and quinquennial death-rates from infectious diseases do not allow for epidemic influence, and must therefore, as I have already urged, be received with reserve. Waiving this point, a careful study of the maps shows that between 1861 and 1895 there has, on the whole, been much more diphtheria in the eastern and south-eastern than in the western and south-western districts of England. That is, there has on the whole been more diphtheria in the districts characterized by relatively deficient rainfall. There are exceptions to this rule, especially that of North Wales. Thus :

Diphtheria : Mean Annual Death-rate per 1000.

	1861–70	1871–80	1881–90	1891–95
England and Wales	·18	·12	·16	·25
North Wales	·29	·20	·17	·19
South Wales	·18	·15	·10	·20
Cornwall	·11	·13	·16	·18

In the first two periods, the North Wales death-rate exceeded that of England, in the third it was practically equal to, and in the fourth it was lower than that of

England. The maps and the statistics on which they are based present many puzzles as to the distribution of diphtheria. Some may represent real facts; many, I believe, are artificial in character, and can only be unravelled by a careful study of annual in addition to decennial or quinquennial death-rates.

If it be agreed that the chief epidemics and all the pandemics of diphtheria of which statistical records are extant occur in exceptionally dry periods of years, there can be little hesitation in believing that the deficiency of rain in some way favours the origin of these epidemics. What is the nature of this unexpected association between epidemic diphtheria and years of deficient rainfall? The analogy of other infective diseases may throw light on this problem. It has been shown independently by Drs. Gresswell and Longstaff that the yearly mortality from scarlet fever is inversely to the amount of rainfall. Dr. Gresswell has further suggested * that "not only the rainfall of the year, but also that for prior years, has influence on scarlatina." Dr. Longstaff showed † that the chief increases in the death-rates from scarlet fever, erysipelas, puerperal fever, and rheumatism in England and Wales occurred in years of deficient rainfall. In the Milroy Lectures for 1895, ‡ I showed by elaborate mortality and sickness statistics derived from the general mortality experience of different European countries, from the general notification experience of Scandinavian countries, and from the experience of large general hospitals in England and other countries, that rheumatic fever is an epidemic disease, of which wide-

* *A Contribution to the Natural History of Scarlatina* (Clarendon Press, 1890), p. 192.

† *Studies in Statistics* (Stanford, 1891).

‡ *Lancet*, May 9th and 16th, 1895.

spread epidemics occur at intervals of a few years, though in the intervals it is never entirely absent from most communities. I also drew attention to pandemics of rheumatic fever, particularly those of 1868, of 1874–75, and of 1884. I also showed that in England the epidemic prevalence of rheumatic fever has always occurred in years of exceptional scarcity of rainfall. In the same lectures I stated: "In the instances where records were available it has been found that when deficient rainfall was, owing to its seasonal distribution, not accompanied or followed by exceptional lowness of ground water, there was no epidemic prevalence of rheumatic fever. It is probable that mere lowness of ground water is not the only factor concerned in favouring rheumatic fever, but this along with some hitherto unknown factor of temperature of soil or rate of flow of ground water. Whether this is correct or not, it is certain that dryness of soil is favourable to the occurrence of rheumatic fever to an epidemic extent." I must draw attention to the following further remark: "The effect of deficient rainfall is not produced immediately. It takes time to develop; and it is warrantable to assume that *the influence of deficient rainfall is exerted as the result of its effect on the subsoil, this effect usually showing itself by a marked lowering of the ground water.*" It will save repetition if I quote the following further remarks from the same lectures: "Low ground water must be regarded as leading to excessive rheumatic fever not by any essential causative relationship between the two. The low ground water is an indication of certain conditions of dryness and temperature of the subsoil which greatly favour the growth of the telluric contagium of rheumatic fever. This being so, it is conceivable that low ground water, when through collateral circumstances it is unassociated with the required conditions of temperature, etc., may not be accompanied by an increase of rheumatic fever, though conversely we never find a high ground water accompanying excessive prevalence of rheumatic fever."

The preceding facts as to diseases which are close congeners to diphtheria, throw considerable light upon the latter disease in its relation to weather and soil. The hypothesis which appears most fully to meet the requirements of the case is that a portion of the life-history of the specific micro-organisms of the above specific febrile diseases is spent in the soil, in a saprophytic stage of existence. It is not surprising, if this be so, that exceptional warmth and freedom from excessive moisture of the soil should lead to an increased multiplication of these micro-organisms, and that they should subsequently become displaced from the soil by rainfall, or become aspirated from the soil, when apart from rainfall the barometer falls, or the interior of a house is at a much higher temperature than the subsoil underlying it. The idea that micro-organisms may be displaced from contaminated soil by means of rain may occasion momentary surprise, as the first thought would be that they would be washed into the deeper subsoil. But this notion ignores the fact that in towns, and even in villages, the area on which direct percolation of rainfall from the ground level can occur is, in these days of impervious pavements and roads, becoming rapidly diminished; while at the same time the entire ground under dwelling-houses is only in a small minority of instances covered with impermeable material, or with this material in sufficient thickness to exclude the ground-air. Consequently when rain falls there is great *lateral* as well as upward displacement of ground-air, and the rainfall, in conjunction with the simultaneous aspirating effect of a lowered barometric pressure, ensures the entry of ground-air into the house.

The only observations in this country as to the connection between ground-water and diphtheria are, so far as I know, those of Mr. M. A. Adams, Medical Officer of Health of Maidstone. His researches, and the conclusions based upon them, are given in a paper which should be consulted in full, as Mr. Adams' able argument can only be fully understood by a study of the ingenious and elaborate diagram accompanying his paper.* His investigation deals with the nine years 1885–93. I am able to comment on it, and on the additional figures derived from his annual report for 1896. The main conclusion is stated as follows: "Broadly speaking, right through the nine years, from beginning to end, a strict concordance may be traced between soil dampness and diphtheria on the one hand, and absence of diphtheria and soil dryness on the other hand." This is evidently in accordance with the generally accepted views as to diphtheria. Stress is laid also on the seasonal incidence of the dampness and dryness of the soil. "As long as the soil is well washed by the winter's high tide, and afterwards dried and aerated during the summer's low tide, all goes well, diphtheria is kept in abeyance; but so soon as these salutary movements are arrested, or their order disturbed, diphtheria gets the mastery, reaching its acme of violence when stagnation is most complete; and I wish to lay particular stress upon the fact that the virulence of the disorder increases with the stagnation of the soil air."

The following table gives some of the data for the years in question:—

* *Public Health*, vol. vii. p. 2 *et seq.*

Year.	Total deaths from		No. of notified cases of Diphtheria and Croup.	No. of inches of Rainfall.	Subsoil Water Levels.	
	Diphtheria.	Croup.			Highest.	Lowest.*
1879	—	3	—	27·2	—	—
1880	2	10	—	29·0	—	—
1881	4	3	—	24·0	—	—
1882	7	14	—	27·9	—	—
1883	5	5	—	24·5	—	—
1884	1	3	—	19·6	—	—
1885	6	9	—	24·6	187·9	212·4
1886	5	9	—	23·0	188·6	211·7
1887	1	2	—	21·7	186·7	208·6
1888	12	5	—	21·4	189·8	203·3
1889	29	4	—	22·8	193·7	204·0
1890	14	—	—	24·4	192·2	206·5
1891	14	—	33	24·9	188·3	201·6
1892	21	—	106	27·3	182·2	204·0
1893	24	—	163	23·3	181·2	203·8
1894	5	3	72	30·8	176·9	199·0
1895	9	—	72	?	186·0	201·2
1896	16	—	54	26·4	179·4	203·9

* In inches beneath the surface of Dr. Adams' laboratory.

The estimated population of Maidstone increased from 31,211 in 1885 to 33,555 in 1896.

It is evident that the epidemic of diphtheria reached its maximum in 1889; but after two years of slight diminution, a second lower maximum was reached in 1892–93, and a third still lower in 1896. The mean rainfall for the years 1879–96 (omitting 1895) was 24·8 inches. From 1883 the rainfall was at or below this level until 1892. There was no evidence of any considerable excess of diphtheria until 1888. The maximum of diphtheria as estimated by the number of deaths, occurred in the next year; but the epidemic continued for several years longer, with a marked recrudescence in the next dry year, 1893. Thus the epidemic conforms to the type already frequently described. It began, and probably owed its genesis, to the succession of dry years; and it continued to a certain extent during several succeeding wetter years. Turning to the subsoil water levels, we see that the lowest minimum level was in 1885, while the lowest maximum level was in 1889; after this the level of ground water gradually rose. Consequently *the epidemic had its genesis in years of deficient rainfall and of low ground water, i.e.* of comparatively dry subsoil. The meaning of the ground-water levels, can, however, only be fully understood by a careful examination of the diagram in *Public Health*, vol. vii. page 3. Dr. Adams very properly lays stress on the maleficent influence (*re* diphtheria) exercised by an absence or a deficiency of what we may describe as the "spring-cleaning" of the subsoil, which is due to deficient rainfall in the preceding winter months. This failure in the "spring-cleaning" of the subsoil implies a drier soil in the earlier months of the year than occurs in more normal years; and thus presumably morbific germs in the soil, which would ordinarily be killed off, are enabled to survive.

Owing to imperfect data, it will be impracticable to consider in detail the circumstances as to ground-water in other places than Maidstone.

A curve of monthly level of ground-water in Hamburg from 1883 to 1895 is given in an article by Dr. J. J. Reincke in the *Deutsche Vierteljahrschrift für öffentliche Gesundheitspflege* (Band xxviii. Heft 3, 1896). Comparing this with Fig. 29, it is evident that the average level of the ground-water gradually sank from 1883 to the end of 1887, and that in 1886, and still more in 1887, the usual "spring-cleaning" of the soil failed almost entirely. These were the two years in which diphtheria was more fatally epidemic than at any other time.

At *Berlin* a curve of the monthly ground-water levels from 1873 onwards (not reproduced) shows a minimum level in 1873–75. Fig. 30 shows an epidemic peak in

1874–75. In 1877 the ground-water fell from the level of the foregoing year, and diphtheria rose in amount. In 1881–82 the ground-water was lower than in any of the preceding years, the spring rise entirely failing to appear in 1882. The years 1882–3–4 had a higher death-rate from diphtheria than any other year. In 1889–92 the ground-water was again very low, with only small peaks of epidemic diphtheria in 1890 and 1893.

In England very few ground-water observations are made, and but few instances can therefore be cited.

At *Croydon* the level of the water in a well in the chalk at Wickham Court has been kept for a long series of years. The very remarkable dip in the level of the ground-water in the three years, 1874–5–6, was associated with an epidemic of diphtheria, which began in 1876, and lasted through the next two years, the ground-water during this time rapidly rising. After 1884 the level of the water in this well steadily fell, and the conditions are probably not due to natural conditions, but to over-pumping from the chalk.

At *Brighton* a chart of monthly levels of the water in the chalk subsoil shows the same relationship between excessive diphtheria and low ground-water, in 1873–76, in 1887–88 and 1890, and in 1893.

In most districts of *London* there is but little gravel overlying its clay subsoil. Consequently there are no continuous ground-water observations. There are, however, observations of the monthly flow of the Rivers Thames and Lea, which derive their water in part directly from surface-water and in part from springs. These observations show the same relationship between dry seasons and excessive diphtheria, as before. In 1858 and 1859 we have already noted that the Thames was so low that the mud gave out a stench. From this came, not the prophesied "fever," but diphtheria.

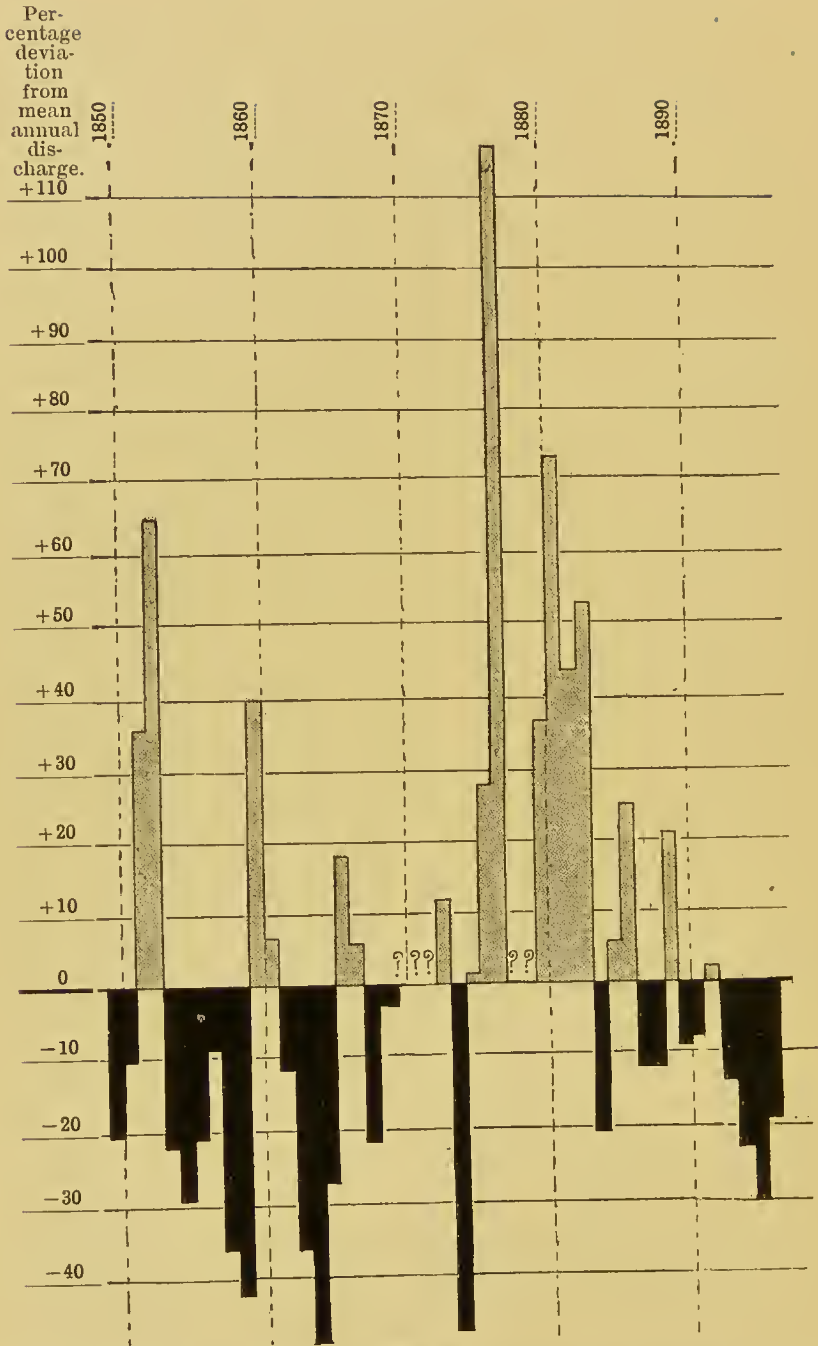


Fig. 57.

Mean annual discharge over Feilde's Weir on the River Lea. Percentage deviation from the mean annual discharge for the entire period, omitting the years 1870-71-72 and 1878-79, for which there are no records.

NOTE.—All the years in which the discharge was below the mean are indicated by black columns. Most of these were epidemic years, but Fig. 13B should be consulted for exact details.

In the following diagram the discharge over Feilde's Weir in the River Lea, at a point in Herts a little above where a large portion of the Metropolitan water supply is derived from it, is shown.

The close connection between years of deficient discharge of water at Feilde's Weir and the occurrence of epidemic diphtheria is very evident. The longest period of deficient water in the river Lea is 1854–5–6–7–8–9. This corresponds to a great epidemic of diphtheria in London. In 1860 the amount discharged over the weir on the Lea was much above the average. In that year diphtheria declined in London (see Diagram, p. 12). Then during the four years, 1861–2–3–4, the discharge of water was again deficient, and diphtheria once more was rampant. In 1868–69 there was some deficiency of discharge of water, but no repetition of the epidemic. In 1874 a slight epidemic coincided with deficient flow of water; and the deficient flow in most years since 1884 has coincided with an enormous epidemic of diphtheria. This can be followed out in greater detail in Fig. 58, dealing with the monthly flow over Feilde's Weir from 1880 onwards.

It will be observed that from 1887 the average discharge of water did not exceed 200 million gallons in any month, except in December, 1891, and in February and December, 1892; while before 1887, with the exception of the two dry years, 1884–85, it was regularly larger in amount. We have here an indication of a similar failure of the subsoil to receive its spring-cleansing, which was noted in Maidstone.

Similar data derived from two different sets of observations (the corresponding diagrams being on different scales) are available for the river Thames. The first (Fig. 59) deals with the monthly flow of the Thames

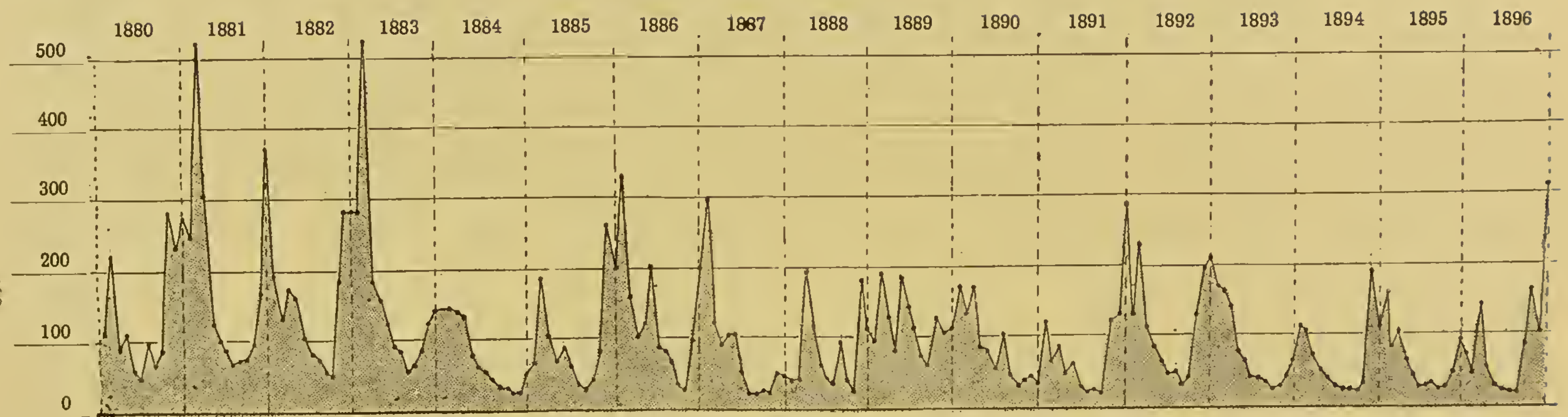


Fig. 58.

Average monthly volume of discharge of water over Feilde's Weir on the River Lea.

NOTE.—The scale to the left indicates the average daily flow for each month stated in millions of gallons. Thus, in January, 1880, the average daily flow was 107 million gallons.

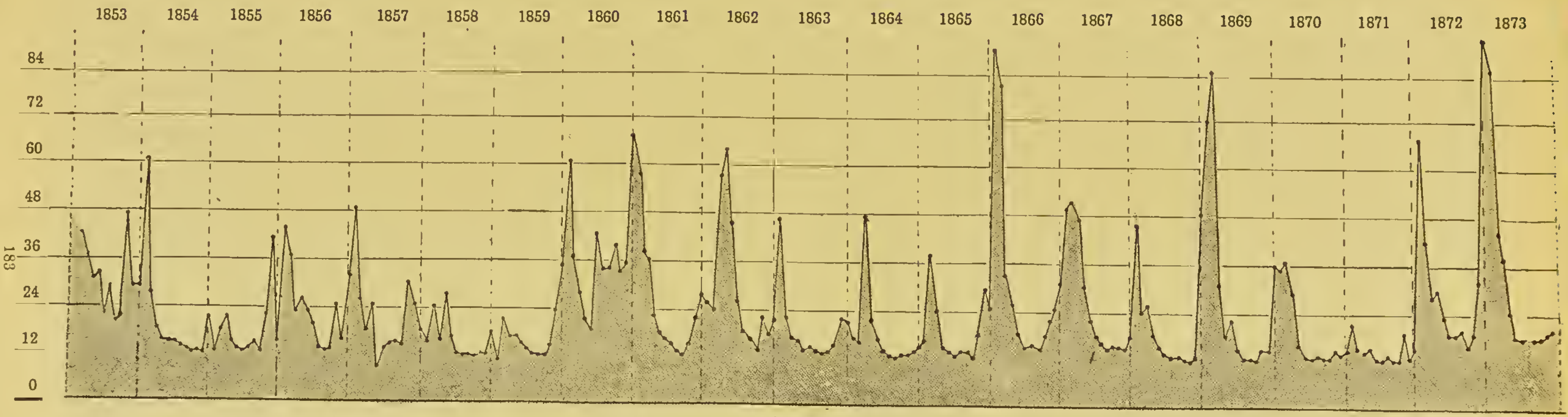


Fig. 59.

Total monthly volume of water flowing in the Thames at Thames Ditton.

Note.—The scale on the left indicates the monthly sums of the daily volume of water in thousands of million gallons flowing down the Thames opposite the Lambeth waterworks, Seething Wells, near Thames Ditton, 1853–73.

at Thames Ditton, 1853–73. The exceptional lowness of the river from 1853 to 1859 inclusive is plainly seen, being greatest in 1854–55 and in 1858–59. The lull in the great epidemic of these years corresponded in 1860–61 to a very great increase of flow of water, the epidemic resuming its course as the flow of water diminished in the succeeding years. The small flow of water 1870–71 was not sufficiently protracted to produce epidemic diphtheria.

The second set of observations is derived from Teddington Weir on the Thames, and is complete from 1883–97. An increasing amount of diphtheria coincided with diminished flow over this weir in 1884–86, while the diminished flow from the middle of 1887 to near the end of 1891 was associated with epidemic diphtheria, as was still more the scanty flow of water from 1893 onwards.

The occurrence of floods renders river-gaugings a somewhat inaccurate test of the true level of ground-water, and it is probable that floods account for some of the sudden rises in Fig. 60, as, for instance, in February, 1893, a year in which diphtheria reached its absolute maximum.

With the imperfect data available it is impracticable to pursue the relation of ground-water levels to diphtheria further. There is great need for the general establishment of stations for observation of ground-water levels and ground temperatures in this country. With each additional year the value of such observations rapidly increases; and a systematic series of such observations will in a few years serve to fill in the gaps of the evidence here set forth.

We may summarize our observations on the *relation between rainfall and ground-water and the rise of epidemic diphtheria* in the following propositions:—

1. An epidemic of diphtheria never originates, in the

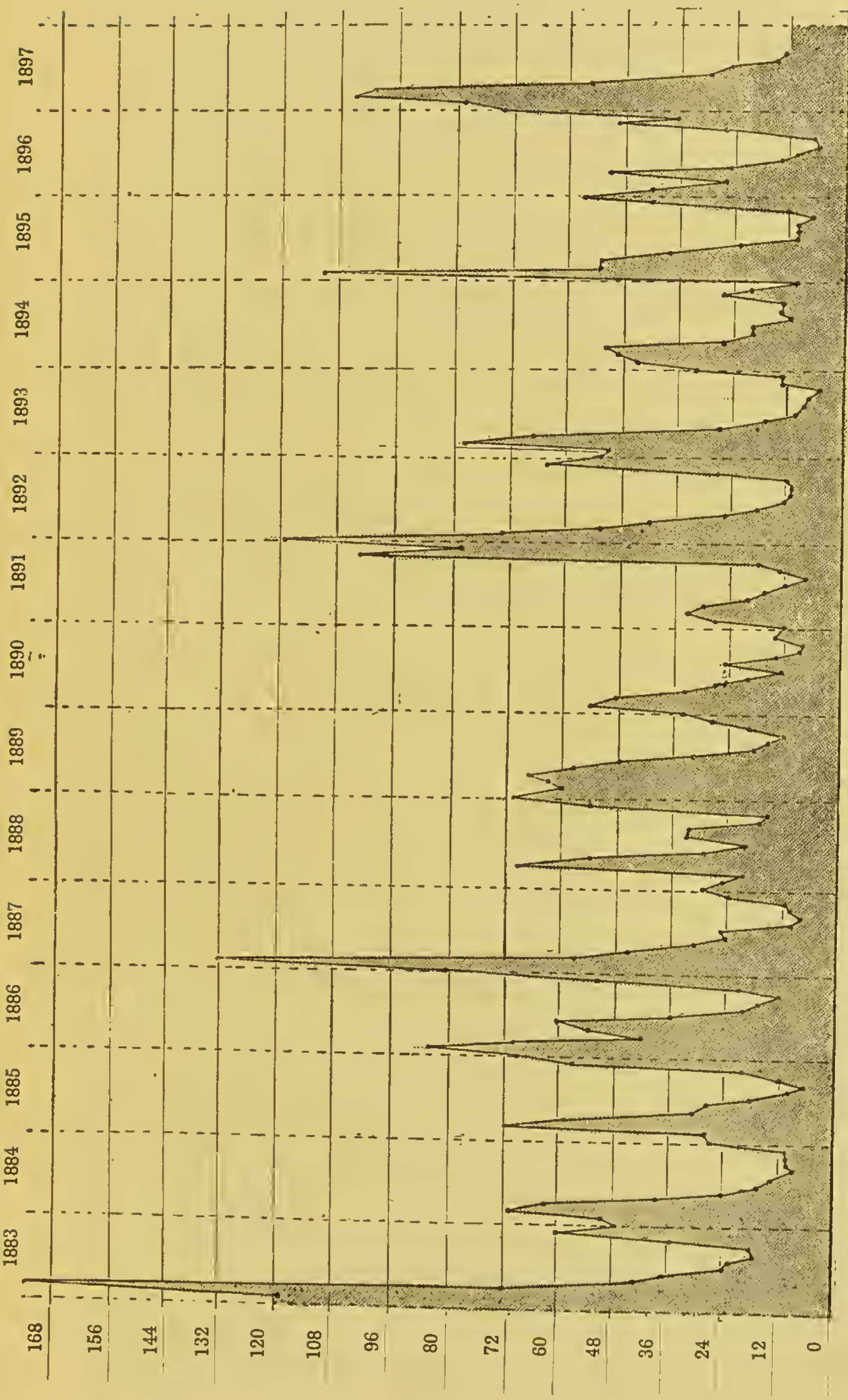


Fig. 60.

Total monthly volume of discharge of water over Teddington Weir on the River Thames.

NOTE.—The scale to the left indicates the total monthly discharge in thousands of million gallons. Thus, during January, 1883, the discharge was 119,700,000,000 gallons.

towns and countries in which I have been able to collect facts, when there has been a series of years in which each year's rainfall is above the average amount.

2. An epidemic of diphtheria never originates or continues in a wet year (*i.e.* a year in which the total annual rainfall is materially above the average amount), unless this wet year follows on two or more dry years immediately preceding it.

3. The epidemics of diphtheria, for which accurate data are available, have all originated in dry years (*i.e.* years in which the total annual rainfall is materially below the average amount).

4. The greatest and most extensive epidemics of diphtheria have occurred when there have been four or five consecutive dry years, the epidemic sometimes starting near the beginning of this series, at other times not until near its end.

5. Dry years imply low ground-water, and we find therefore in the years of epidemic diphtheria that the ground-water is exceptionally low. The exact variations in the ground-water which most favour epidemic diphtheria cannot with the data to hand as yet be stated; but it is probable that when this is cleared up, it will become clear why in exceptional years which have a deficient rainfall epidemic diphtheria is either absent or but slight.

The preceding propositions enable us to formulate a *working hypothesis of the causation of diphtheria.* The specific micro-organism of this disease has a double cycle of existence, as have the specific micro-organisms of enteric fever, erysipelas, scarlet fever, rheumatic fever, etc. One phase is passed in the soil, another in the human organism. One is saprophytic, the other parasitic.*

* It is not contended that there is a *regular* alternation of saprophytic and parasitic generations; but that such alternations do occur.

It is not strange, therefore, that the epidemic prevalence of all the above diseases is favoured by deficient rainfall, if this is sufficiently long continued. This deficient rainfall implies a low subsoil water, and a subsoil above the level of this water, which is relatively dry and warm, probably the *optimum* conditions for the saprophytic life of the above pathogenic micro-organisms. The causes of the transition of the diphtheria-bacillus from the saprophytic to the parasitic phase of life may be surmised both as regards (*a*) season and (*b*) years of special epidemic prevalence. Diphtheria is most prevalent in autumn and in the early winter months, when the optimum temperature and the optimum degree of humidity of the soil are rapidly disappearing or have departed. It is also most prevalent after the wet weather occurring in or immediately following exceptionally dry years. Both these conditions tend to raise the ground-water and to drive out any pathogenic micro-organisms from the soil.

The preceding working hypothesis may appear to give undue importance to *climatic conditions* as contrasted with *personal infection*. It must be remembered, however, that one of the main objects of this book has been to show, from exact official statistics, the gradual spread of diphtheria from town to town, and from country to country. This has been indicated in repeated instances. There is no reasonable doubt that *personal infection is the chief means by which diphtheria is thus spread.*

Personal infection does not, however, explain why in some years diphtheria, although present in a district in an endemic form, does not spread; while in another year, in which only the same opportunities of personal infection occur, it becomes extensively epidemic. Still less does it explain the occurrence of widely scattered epidemics and even pandemics in certain years. To explain these the operation of wider general causes must be pre-supposed. It might be that the susceptibility of entire populations to the infection of diphtheria increases at times, though this is improbable; or it might be that the diphtheria-bacillus under certain conditions becomes more actively virulent and infective—more remote from its saprophytic phase of life; and that, thus, persons who can resist the ingress of the feebler, fall victims to the more powerful micro-organism. The latter is probably the correct hypothesis; and the evidence already given clearly points to the conclusion that of the external cultural conditions leading to increased virulence of the diphtheria-bacillus and greater readiness for assuming a parasitic life, exceptional deficiency of rainfall and consequent exceptional deficiency of moisture in and exceptional warmth of the subsoil form an essential part.

CHAPTER XIX.

CONCLUDING REMARKS.

It appears desirable, in conclusion, to state in a few words what degree of confidence is claimed for the facts and arguments set forth in the preceding pages. A careful distinction must be drawn between facts and arguments, as they evidently stand on a different footing. The degree of accuracy claimed for the statistical facts pictorially represented in the sixty figures scattered throughout the text has been already stated. After spending many laborious hours for several years past in the critical study of these figures, I am confident that they tell the essential truth. The changes produced by alterations of nomenclature and other causes are of minor importance; and the peaks and valleys of the preceding diagrams represent real epidemics and real inter-epidemic periods. Absolute accuracy is impossible; and it may be that here and there errors have crept in. Such errors will not, I believe, in any single instance alter the statements made in the previous chapters as to the years of epidemics and of intervals between them. Although absolute accuracy has been aimed at, approximate accuracy amply suffices to bring out the essential character and meaning of the great facts set forth in the preceding sixty diagrams, and such approximate accuracy has, at the least, been attained.

The arguments based upon the statistical premises of the preceding chapters and the general law,—an attempt to establish which has been made,—invite criticism, and they are submitted with that object. An attempt has been made to examine epidemic diphtheria from a view-point unprejudiced and unbiassed by the accepted teaching upon the subject. Not many years ago the mention of the word "diphtheria," or even of the less exact word, "sore throat," created a presumption in the minds of the majority of medical men that *drain-poisoning* was operating. (Possibly it was, in a minor sense, by increasing the vulnerability of the patient.) Now there has grown up an equally erroneous general impression that the occurrence of diphtheria—apart from personal infection, which all agree is a most potent factor—is intimately associated in its origin with dampness of soil, and that *ceteris paribus* diphtheria may be expected to be more rampant, for instance, on clayey or water-logged soils than on soils that are pervious and dry. I have given my reasons for disagreeing *toto cœlo* with this conclusion. These reasons must in their turn receive criticism, and as the result of further accumulation of confirmatory or contradictory instances, it will be proved or disproved that an essential factor in the production of epidemic and still more of pandemic diphtheria is the occurrence of a succession of years of deficient rainfall, associated as they must be with abnormally dry conditions of the soil and subsoil.

Every general truth in science is hedged round with exceptions and modifications. Instances have been quoted in the preceding chapters which seem to prove the reverse of what the general law states, or to make the statement of it appear inaccurate. Such exceptions do not show that the general law is untrue, or that for practical purposes we cannot forecast the future of diphtheria on a national and international scale from this general law. It is a safe rule that winter is colder than summer. If the mean temperature during the next summer should be lower than that of the present exceptionally mild winter, the rule will remain true in the *majority* of cases. So with diphtheria. In the majority of instances epidemics occur under the climatic conditions previously detailed; and the occurrence of a marginal fringe of doubtful or even occasionally of minor contradictory instances does not diminish the value of this general law as applicable to the majority of epidemics.

The main conclusion stated in the preceding pages may on the first blush produce a depressing sense of comparative helplessness, such as one feels in connection with the return of epidemic influenza since 1889. If the occurrence of pandemics of diphtheria is governed largely, if not chiefly, by meteorological conditions over which we have no control, what scope is there for the intervention of preventive medicine? Before answering this question, let it first be clearly stated that we must have the truth at any cost. If the statement of the truth by implication means that our preventive measures are but Canute-like attempts to stop the inflowing tide, still it is well that the truth should be known. But this is not a correct view of the case. Diphtheria is spread chiefly by personal infection. This personal infection is immensely more potent in epidemic that in inter-epidemic years—a fact which should lead to redoubled efforts to prevent personal infection during such epidemic periods, rather than to a fatalistic inertia. Similarly redoubled efforts are required to prevent ground-air from gaining admission into houses, and to render more wholesome the soil in districts in which diphtheria has become endemic. How this can be done in towns, how the soil can, without more open spaces than are obtainable in most of our great cities, be made to resume its virgin salubrity and purity cannot be stated here. It is one of the greatest problems of public health. But to assume that because we do not yet know how to exterminate diphtheria, or because we cannot hope in our day to be entirely successful in preventing its spread, it is therefore useless to attempt anything, would be as unwise as it would be for a city council to dismiss their fire brigade staff and dispose of their fire-preventing apparatus, because the staff had not been successful in at once extinguishing every fire, or because the city council were impressed with the fact that the present appliances for extinguishing fire are of a very imperfect character.

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Butler & Tanner, The Selwood Printing Works, Frome, and London.